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THE COUNTRY OF THE BRASSMEN.

LITTLE is known of the many oil trading stations of the Niger and its tributaries, except within commercial communities and to those who have friends at the "factories," where at some places, such as Yala, no means of communication exist during the six or eight months of the "dry season." The country for miles and miles around is one vast mud swamp, with nothing growing out of it but dense vegetation. The existence of the swamp is caused by the annual rise of the river Niger. It overflows the low-lying banks, and

KING KOKO IN HIS WAR CANOE.

year after year the land is flooded, making the trees appear like plants stretching themselves out of the water! In due course the river falls to its normal height, leaving the forests covered with water, which slowly filters through the earth; and this process goes on until the level of the river is reached. The vegetation is so dense that within the jungle all is like the darkness of night, the sun never penetrating through the thick foliage of the trees.

Proceeding further up the river, the banks are higher—due, perhaps, to the fact that the river in its flow encounters no resistance through tidal influence. Traveling still further up, the forests gradually give way to banana and plantain "farms," which are dotted all along the banks.

The natives depend much upon fish for food, and it is due, perhaps, to their calling in this respect that the villages are situated at the river side. There are some villages inland, such as Nimbe (captured and burnt by the recent punitive expedition), which are approachable by creeks, up and down which the natives pass in their small canoes. When an expedition is sent to attack any of these villages, it is always by water, the dense jungle rendering a land attack impossible. These creeks are difficult of navigation, except to the natives themselves. The great disaffection and bad feeling which have existed among the natives of the Niger (which will probably call for a thorough investigation) are owing, it is said, to the monopoly of trade by various companies, which has reduced the revenues derived by the chiefs, and left the natives positively without the means of subsistence. The prohibition of the importation of firearms and spirituous liquors has also given rise to considerable discontent, and provoked smuggling on a large scale, which is being rigorously put down. Our illustration, taken from a photograph, shows one of the Brass chiefs, King Koko, starting on an expedition in his war canoe.—The Graphic, London.

[FROM THE NINETEENTH CENTURY.]

THE GREATER ANTIQUITY OF MAN.

IT is instructive to look back and note the changes of opinion that have taken place within the last half century respecting the age of man on the earth, whether among geologists or archæologists. With the latter we are not concerned. The former I have followed from the beginning. So late as 1858 the belief in the recent origin of man remained unshaken, and for this geologists themselves were largely responsible.*

It was only in 1847 that the Geological Society declined to publish a paper which would have had the effect of showing that man co-existed with the extinct Quaternary mammalia, and would therefore be older than the age hitherto assigned, of about 6,000 years. Nevertheless it had not escaped the notice of a few independent observers that there were facts which, if admitted—and sufficient proofs were shortly forthcoming of their truth—must have led to a modification of the prevailing belief. The Rev. J. MacEnery, a Roman Catholic priest living at Torquay in 1825-30, exhumed from the celebrated bone cave known as Kent's Cavern flint tools, evidently worked by man, in definite association with the remains of the mammoth, rhinoceros and other extinct animals, at a depth of several feet beneath the surface and in undisturbed ground. This discovery was noticed by so excellent a geologist as the late Mr. Godwin-Austen, and confirmed a few years later by a local committee, but the facts still failed to obtain recognition.

Here the subject rested for some years. There was a reluctance to look the question in the face. The

* As a matter of history it may be recorded that so late as 1858, only six years before the general conversion, a distinguished geologist contended in an ingenious argument that man was of recent origin, and that it was not on the evidence of such intermixtures of human bones with those of the extinct animals, as reported in the caves of England and Belgium, that we ought to admit readily either the high antiquity of the human race or the recent date of certain lost species of quadrupeds.

fact was rejected as impossible; but no special inquiry was made. In the meantime a French gentleman—not a geologist, but an experienced archæologist—residing at Abbeville, and acting on theological rather than on geological grounds, as well as in belief of the Diluvial theory current among the earlier geologists, which attributed all the superficial deposits of sand and gravel to the effects of the Mosaic deluge, became imbued with the idea that, if such were the case, the remains of antediluvian man ought to be found in those deposits. He accordingly set himself to search. It was well known that remains of the mammoth, woolly rhinoceros, hyena, reindeer, etc., had been found in beds of Quaternary age near Abbeville and other places in the valley of the Somme. There he therefore commenced, nor was he long without his reward. True, he found no remains of the human skeleton, as he expected; but he found flints fashioned into shapes which his acquaintance with the flint implements and weapons of the stone or Neolithic period led him to conclude were the work of human hands. There was no exact identity of forms, yet a general resemblance so close that it was evident that the makers of the two sets of implements had the same objects in view, both sets being alike fitted for defense, offense, and various domestic purposes. At the same time there were fixed points of difference, such as that the stone period implements were mostly ground and polished, while the drift implements were rough and unpolished; and, though clearly made to serve similar purposes, there was a certain difference in the patterns.

The absence of human bones presents, however, no difficulty. In the first place, while wild animals lived in vast numbers during the Quaternary period, early man existed but in small communities; secondly, his bones, if exposed, would speedily decay; or be removed, if underground, by the infiltration of the surface waters, unless placed under favorable conditions for their preservation, such as if covered with a bed of clay, or when they were embedded in the argillaceous deposits of bone caves. So great is this property of infiltrating waters that there exist beds of gravel, originally consisting of insoluble siliceous elements mixed with pebbles of chalk and oolite, in which the latter two calcareous elements have been completely dissolved out, like so many lumps of sugar, and the indestructible siliceous pebbles alone are now left. Man also could avoid many dangers to life to which animals were exposed.

The statements of M. Boucher de Perthes, which were certainly not free from the introduction of some questionable facts and figures, were treated with neglect, and it was not until the late Dr. Falconer, whose Indian experience had led him to believe in the antiquity of man, visited Abbeville in 1858, and urged the writer—who had already satisfied himself that the previous discoveries in Belgium and Devonshire constituted a strong prima facie case in its favor, and had, on the first report of M. De Perthes' discovery, been intending to look into the geological evidence—that the investigation was undertaken. In April, 1859, I was able to corroborate the accuracy of M. De Perthes' discovery,* and witnessed the finding of two undoubted worked flints in a mass of shelly shingle with mammalian remains, at a depth of about twenty feet, in a pit at Menchecourt, near Abbeville, and subsequently of one at Amiens in a bed of high level gravel with fluviatile shells. Sir John Evans showed likewise that long previously similar implements had been found under the same conditions at Hoxne, in Suffolk, and in Gray's Inn Lane, London, but had been passed unobserved by geologists.†

This satisfied men of science that Palæolithic man existed in post-glacial times, and that the chronology of the human race would have to be widely extended.

Shortly afterward similar Palæolithic flint implements, in association with similar mammalian remains, were found in the valley of the Thames, in the neighborhood of Salisbury, of Bedford, and elsewhere in the south of England. They were likewise discovered in many parts of France, in Spain, Italy, and elsewhere in the south of Europe. Nor was it long before they were found on the north coast of Africa and in Egypt; likewise eastward in Syria, Arabia, in the Indian peninsula, and elsewhere.

In the meantime my report, and those of some geological friends whom I had invited to accompany me, had led Sir Charles Lyell to visit the Somme valley, and to announce the discovery at the meeting of the British Association at Aberdeen in September, 1859, and afterward to publish all the facts bearing on the subject in his popular Antiquity of Man, in 1863.

We need not pursue this stage of the subject further; suffice it to say that the discovery, so long rejected and then looked upon with doubt, speedily became an accepted fact, and the antiquity of man enrolled among the gains of science.

Here the question rested for a time. But were we to stop there? Was there any reason to suppose that the relics met with in the valley drifts were the work of the earliest race of men? The workmanship on some specimens of the Palæolithic implements was not very much inferior to that of Neolithic times; and what was known of the human frame indicated but slight, if any, inferiority in its physical structure to that of modern man. All led one to suppose that ruder ancestors preceded Palæolithic man.

Isolated specimens were discovered in this country from time to time in positions which suggested a greater antiquity; but, as in the case of the early Palæolithic discoveries, they failed to receive the attention which many of them deserved. It was the same on the Continent, where, however, certain of our colleagues would carry back man to Miocene times; but many of these cases have either proved illusive or else want confirmation. A recent discovery in Burma also associates man with Miocene strata. This again wants confirmation.

My object at present is, however, with a more remarkable case at our own doors, a case which relates not to isolated specimens, but in which the finds, numbered at first by hundreds, now count by thousands of specimens,‡ and which would carry man back to early glacial if not to pre-glacial times, and thus give him the "greater antiquity" surmised as probable on other grounds.

For the discovery of this new location we are indebted to Mr. Benjamin Harrison, a keen and enthusiastic naturalist trading in the picturesque village of Ightham, in Kent. The small stream of the Shode passes through the village and flows into the Medway at a short distance east of Tunbridge. In both the high and low level gravels which flank the valley, Mr. Harrison, prompted by the discoveries in the valley of the Somme, found flint implements of the ordinary Amiens and Abbeville Palæolithic types. These I have already described.* But this did not satisfy him, and our business now is with older ground.

At a short distance north of Ightham rises the escarpment of the North Downs, there from 600 to 700 feet high, and forming part of the elevated chalk plateau which slopes gently northward toward the Thames. There Mr. Harrison set to work. No more unpromising ground could have been chosen for further search. There are no streams and no valley drift beds. But the habit of search prevailed; Mr. Harrison persevered, and soon became aware that in the southern drift, thinly scattered over the surface of the plateau, there were some flints which had the appearance of having been chipped and worked by human hands. They were, however, so rude and so little removed from natural fragments of flint, that when a collection of several hundred specimens was exhibited at a meeting of the Geological Society they were by many treated with derision. In my opinion, however, there could be no doubt of the artificial character or of the greater age of the majority of the specimens; but at that time very few shared in this belief.

The skepticism arose from two causes—first, with respect to the rudeness of the implements, which led to the denial of artificial work; secondly, to the absence of an important link in the chain with regard to their geological age. We will deal with the last difficulty first. It is a difficulty that arises from the absence of any beds of known glacial age associated with the plateau drift. Nor, with the exception of the Crag beds (Diestian) of Lenham, which underlie the plateau drift, are there any beds of pre-glacial age present. The absence of any organic remains constitutes another difficulty. None exist. But are we therefore to retire discomfited and abandon the inquiry? It has long been known to geologists that the glacial deposits of Hertfordshire and Essex do not extend to the south of the Thames. Why, then, expect them in Kent? All that can be done is to take the case as it stands, and if we cannot enter by the front door, let us see whether a side entrance cannot be found. Has it been sought for? Perhaps it has been felt that it is easier to lie down at the foot of a wall than to scale it.

There is really a perfectly practicable side door open to us in the relative position of the different drift beds, and in the extent of denudation or valley erosion that took place between the deposition of the several drift deposits—a work of demolition which marks time as effectually as does that of construction.

It was evident, for various reasons, that if the implements were the work of man, they must have belonged to a much older race than man of the valley drifts. How was this to be proved? I will endeavor to answer the question as briefly and with as little technical detail as possible. It has, in the first place, to be remembered that what I have to say of the topography of the district has reference to it at the time when the drift, associated with the flint implements on the summit of the chalk plateau, was spread over its entire surface, and, therefore, before the dry chalk valleys which now intersect it were cut out and formed, and when also there was higher ground to the south, where now the hills and valleys of the Weald form part of the pleasant and fertile garden of Kent.

At present the rainfall on the plateau sinks into the chalk and escapes by underground channels into the adjacent deep river valleys. At the remote period here alluded to, these valleys did not exist, and the rainfall escaped by wearing for itself channels on the clay-covered surface of the level pleateau, which was at that time dominated by higher ground to the south, while the whole line of main drainage was to the north in the Thames valley. Here, then, was a high level plain of chalk covered by argillaceous and drift beds, which thus became furrowed by the escaping rainfall; and as the furrows gradually deepened they ended in the formation of the existing chalk valleys. It will, therefore, be seen that these valleys must be newer than the hills through which they are cut, and consequently that the beds of sand and gravel, with the remains of the extinct mammalia, together with the flint implements of Palæolithic man, found in these valleys, must also be newer than the drift scattered on the summit of those hills. This is a simple proposition, but is one seemingly not yet mastered by some of our geological friends.

The great valley of Holmesdale and the river valley of the Medway (part of this eroded series) form deep channels, the one parallel with the chalk escarpment and the other cutting through it; and in both of these we find abundant traces of Palæolithic man, associated, where the conditions are favorable, with the remains of the mammoth, woolly rhinoceros and other animals. The significance of this fact cannot be too strongly insisted upon.

A preliminary objection was raised against our interpretation of the plateau implements on the score of their alleged indefinite shapes, and supposed absence of recognizable signs of workmanship or design. This led many to reject them altogether as the work of man. But, rude as a large proportion of the plateau implements are, it soon became apparent that a certain number of them could be resolved into distinct groups, and that particular forms prevailed, which constituted definite types, such as—

1. Scrapers of various shapes. These predominate; but, unlike the scrapers of the Stone and Palæolithic periods, which form each a separate tool designed for the one object alone, these plateau scrapers, though sometimes made for use as one implement alone, are most frequently combined on the same flint with other forms of tools, such as drills, trimmers and hammers; or else a flat or chisel-shaped scraper will have at the other end a circular scraper. Thus the one implement may serve for several purposes. It is a case of generalized, preceding special, forms.

2. Other scrapers have been formed out of split Tertiary flint pebbles, sometimes split naturally, at other times artificially. The edges are trimmed generally all round, so as to act as a rough scraper in whatsoever position the pebble may best be held. At the present day a similar practice prevails among some North American Indians, who, whenever in want of a scraper, select a pebble, which they split and then trim the edges. They rarely keep the old scraper, fresh ones being so easily obtained. This tool is called a pashoa or scraper, and is used by the Shoshone Indians to dress skins.

3. Another common pattern is a flat, roughly pointed implement, of which the sides form scrapers, while the central point might serve for other purposes. In some of these implements the point is very slightly protuberant, and has lateral bow-shaped scrapers on either side. This is a form peculiar to the plateau implements.

4. A fourth and peculiar type of scraper is in the form of a crescent, from one to three inches in breadth. Sometimes these are made out of a thin flat piece of flint; at other times they are rounded and shaped like a bent forefinger, and are about the size of one. They may have been used for scraping bones or sticks. An iron tool with a similar curve, termed a "drawshave," is now used in Kent for scraping hop poles.

5. Other forms of these rude implements seem to have been adapted for use as drills, small hand picks and other objects.

6. Flakes, so common in the valley drifts, are rare, and only a few show the "bulb of percussion," which is so characteristic of artificial fabrication. A sharp blow on any flint always results (as with the Suffolk flint knapper's work of to-day) in a more or less prominent bulb. There are geologists who assert that they may have been formed naturally—an assertion which might be as difficult to disprove as it would be to prove. Flakes simply for cutting purposes are rarely found, while they are common in the valley drifts and in Neolithic depots.

7. Besides these more usual forms, implements of the spear-head type, so characteristic of the high-level gravels of the neighborhood of Amiens and in the Thames valley, and of the flat ovoid-shaped implements common in the lower gravels of Abbeville, are occasionally met with. These plateau specimens—true prototypes of the later Palæolithic implements—are, however, very much ruder and smaller than the others; and, though a few rare, finely worked specimens are sometimes met with, there is reason to believe that, like the Neolithic implements also found in the same association, they are of a different and more recent age.

8. But by far the larger number of the plateau specimens are shapeless fragments of flint, usually flat, stained brown, and merely chipped or roughly trimmed on the edges, just as at the present day an Australian savage will take pieces of bottle glass or telegraph insulators and chip them into some rude form adapted to his simple wants. Some of these flints are roughly square, others long or pointed; but all show artificial chipping or trimming on the edges, though whether so chipped by design or from use in chipping or breaking other flints it is not always possible to say. They are merely rude natural flint fragments which happened to have a shape that seemed available for the object the searcher had in view, yet having no definite pattern. Still the work is evidently artificial, though to an unpracticed eye it may not always be easy to discern. It is, in fact, often difficult to draw the line between the natural flints and those which have been thus manipulated. From the circumstance also of their having been merely natural flints picked up on the surface their original aspect often predominates over the subsequent work.*

Nevertheless, it is clear that the flints have been intentionally modified, "for we know of no natural agency which could produce the signs of work so abundantly shown upon them."† Not only is the workmanship of the rudest character, but the specimens have frequently been so much worn that the work is commonly blunted and often obscured. Although, however, there are hundreds of specimens having undefined forms, a large majority even of these will still be found to have relations more or less distinct (often very faint) with the several types just described. It is evident that we are here in the presence of a very simple, and, may be, nascent intelligence. The work is, in fact, such as we might expect from a race of a time so remote from us, and so remote even from the Palæolithic race of men; for whereas at the time of the valley gravels this land had assumed its present main physiological features of hill and dale, at the time of the plateau drift these surface features did not exist. We may judge from this how great was the distance of time which separated the two races.

But, says one critic, rudeness of form is no test of age, and leaves it to be inferred that these specimens are no older than other rude forms of later ages. Who of the advocates of the plateau implements ever said that it was? I know of none. We particularly remarked in 1892 that rudeness of form alone was no proof of antiquity, and that there were plenty of very rude specimens of the valley types.‡ We would again emphasize the fact that there are rude implements not only of the valley gravels, but also of Neolithic times, while among the stone implements of living savages there are many as rude as those of the plateau group.

Each epoch had, however, its typical forms, and these are broadly persistent, howsoever rude the specimens may be. In the Neolithic period ax and chisel shapes predominate; in the valley gravels the long-pointed and spatula-shaped implements are characteristic of the period; and in the plateau group various forms for scraping and hammering prevail. There are, no doubt, pointed forms in the plateau group, but they have a different cachet from those of the valley group, as these again differ from those of the subse-

* Trans. Royal Society for May, 1859.

† Trans. Society of Antiquaries for 1859, vol. xxxviii.

‡ In Mr. Harrison's collection alone there are now 3,589 plateau specimens. It must be borne in mind that these flint implements are indestructible, and that their numbers may represent the work of many successive generations. The total number found up to the present time by the several collectors cannot be far short of 5,000.

* Quart. Jour. Geo. Soc. for May, 1891.

* The various forms of the plateau implements are figured in the Journal of the Anthropological Institute for February, 1892, and rearranged, with additions, in the writer's Collected Papers on Controverted Questions in Geology.

† Letter of Canon Greenwell to the author.

‡ Journal of the Anthropological Institute, February, 1892.

quent Stone period. There are, besides, certain generalized forms which persist throughout all the periods, though perhaps varying a little in some minor details. Simple flakes likewise, more or less worked, are found in all three periods.

Another critic remarks on the fact that pointed forms of the Amiens pattern occur on the plateau, and would have it, therefore, that all other forms also belong to the same race of Palæolithic men. But in the high and low level valley drifts types of the same character are repeated, notwithstanding their difference of age; while closely allied Palæolithic forms occur occasionally among Neolithic specimens, yet no one would seriously contend that the relative age of the two was affected by the circumstance.

Others would have it that the implements are found in a peculiar bed of clay which is of local origin, and is, therefore, not a drift deposit. We, however, have never found them in that particular flinty bed when undisturbed, though they are met with on its disturbed surface. The drift on that surface is certainly not of local origin, as is shown by the presence in it of fragments of strata derived from the hills some miles distant to the south.

Again, it has been contended that the small valleys began their career on the plateau and finished as the larger river valleys, and consequently that they all belong to the same epoch—forgetful of the great lapse of time between the beginning and the end of the valley excavation.

Some critics have even gone so far as to deny the workmanship of the flints, because, as they contend, they show no bulb of percussion. But how many of the valley specimens show such a bulb? Certainly not one in a hundred or more. Where the trimming has been done by pressure or by slight chipping it is not likely there would be any. The argument, however, is futile, because the fact is that some, though very few, specimens of the plateau implements do show such a bulb.

It has also been frequently asserted that these implements are natural forms produced by the friction of the shingle on the shore or in the beds of rivers. Challenged to show any such natural specimens, those who have made the assertion have been unable, although nearly three years have elapsed since the challenge was given, to bring forward a single such specimen. If, moreover, implements were formed in that manner, they should be found in gravel beds of all ages and origins. So far from running water having this constructive power, the tendency of it is to wear off all angles, and reduce the flint to a more or less rounded pebble.

Such have been the main adverse arguments urged against the plateau implements.* It will be seen that most of them have been directed against conditions assumed apparently under misapprehension of the facts. We cannot, however, pretend to deny that there are yet some unsolved difficulties, in the removal of which let us hope that, after more of our critics have visited the ground, we may have their co-operation.

That there should be hesitation in accepting the artificial character of some of the work we are not surprised. Were it not for the circumstance that design is shown in the frequent repetition of the same form, we could well understand that there should be some skepticism.† Substituting "form" for "color," might we not look upon this as a condition parallel with that of color blindness? In the one case certain colors are invisible to the patient; in the other certain marks fail to be apparent to his apprehension.

One point of difference between the valley and the plateau forms is that the former are commonly large and massive, and not adapted for use in the hand (although there are marked exceptions to this), but would appear to have been fixed to the end of a pole or stick for use as weapons of offense or defense; on the other hand, the plateau implements are mostly of small size, and fitted for use only in the hand. This is further to be seen in the fact that they are generally worked round all the edges, so that they could be used in different positions and on all sides. This absence of the large massive implements is a noticeable feature. Whence could this have arisen? The elephant (E. antiquus), rhinoceros (R. etruscus), bear (Ursus spelæus), and various formidable carnivora had already appeared on the land, so that weapons of defense would appear to have been as much needed as in the subsequent Palæolithic period. Was it from want of skill or want of power? Were those men so devoid of intelligence or so unable to cope with their feral enemies that they sought shelter and refuge in the trees of the forest? Can we venture on a conjecture that they were in that sense an arboreal race?

These are questions we cannot pretend to answer. What little is known of Palæolithic man leads us to suppose that he differed but slightly in structure and habits from the modern savage. Of the structure of the plateau man we know nothing. All traces of his frame, as also of those of the local contemporary mammalia, which might have inhabited the same wilds, have disappeared in the long roll of ages. How surely this can be accomplished in permeable drift deposits we have already (ante, p. 618) pointed out, in the instance where the solid calcareous contents of a bed of gravel have been removed as completely as if they had never existed.

Of what use, then, were the implements? They could at least be used for hammering, for breaking bones, for scraping skins, bones and sticks, and for chipping and trimming other stones for use. All this points to a very simple and primitive race whose wants were few, and who, perhaps, lived largely on fruits and roots. There may have been races yet older in other parts of the world, but in Britain none older have yet been met with. What their age may be, in terms of our chronology, we cannot say. In geological chronology we have reason to believe that they preceded or were contemporaneous with some part of the Glacial period—that is to say, if we are right in supposing that the great valleys of Holmesdale and the Medway were excavated by the rains and ice of that period

* The reader will find discussions in which these various objections are advanced in the Journal of the Anthropological Institute for February, 1892, on the occasion of the author's paper on the plateau implements; and more recently on the occasion of Professor Rupert Jones' address on the same subject at the Oxford meeting of the British Association in August, 1894, and reported in Natural Science for October that year.

† The same skepticism was shown by a former generation with respect to the implements from the valley drifts.

—while a limit to their antiquity is drawn by the superposition of the plateau drift on the Lenham Crag of Pliocene age.

Of the greater antiquity, therefore, of the plateau men we think there can be no doubt. Some estimate of the remoteness of that time may be formed by considering the position and age of Palæolithic man. As I observed on a former occasion,* when, thirty-five years ago, the barriers which restricted the age of man to a limited traditional chronology were overthrown by the discoveries in the valley of the Somme and in Brixham Cave, the pent-up current of geological opinion tended to the other extreme of assigning to man (post-Glacial) an antiquity unwarranted by the facts. Measured by our own limited experience of natural agencies, the deepening of the valleys, the life of the successive generations of the Pleistocene mammalia, and the dying out or extinction of a large number of species were thought to demand a very long period of time. Consequently it was at first suggested that the Glacial period commenced possibly about a million years since, and that the post-Glacial period had lasted about 200,000 years.

It was felt, however, on the other hand, that the very large proportion of existing species of land and marine animals which lived during the Pleistocene period, and had since undergone no change, combined with the stationary condition of man himself during so long an interval, presented serious objections to adopting such lengthened periods of time. On neither side, however, were the conclusions based on any definite data. To the uniformitarian the assumption of limitless time was an indispensable need, and, therefore, in the absence of any available geological scale, geologists were led to adopt the astronomical chronology of the late Dr. Croll, who, after first suggesting the higher figures, concluded that the insetting of the Glacial period took place 240,000 years ago, and the end of the post-Glacial period 80,000 years ago.

The extreme opinions, which, in reference to the Quaternary period, dealt with millions of years, are now probably held by few; but still many and possibly the majority of geologists assign to the Glacial and post-Glacial periods measures of time which involve for the antiquity of man the vast periods just mentioned. Nevertheless Dr. Croll himself considered that the modern doctrine of uniformity had led geologists to overestimate the length of geological periods. In the result, the discussion of the hypothesis still left the disappearance of Palæolithic man at a distance of 80,000 years from our own times. We, however, can find no geological warrant for this great interval. There is no proof that Neolithic man reigned throughout so long a period. Time has been too much used to explain all difficulties. Time, it is true, is illimitable, and there is no occasion to be niggardly in its use; yet on the other hand, there is no occasion for prodigality,† or to employ it in support of problems when other explanations fail, and time is resorted to as the deus ex machina.

Of the length of the reign of Palæolithic man no definite measure has been suggested. We have on previous occasions endeavored to form some approximate estimate. It is for those geologists who place his disappearance at a distance of 80,000 years to say what additional term they would require. For our own part we know of no geological evidence to support such very long terms. They rest altogether upon Croll's hypothesis, which entirely fails to satisfy the geological conditions of the tertiary and secondary formations; and, with the failure of that hypothesis, those measures of time must also fall. We need not here repeat the reasons which led us to conclude that the appearance of Palæolithic man—that is to say, the man of the valley drifts—does not extend probably beyond a distance of about 20,000 to 30,000 years, and his disappearance at from about 10,000 to 12,000 years from our own times.

Palæolithic man is admittedly post-Glacial. Between him and Plateau man, or as it has been suggested he should be termed, Eolithic man, is the wide gulf of the period of extreme glacialism, when this land was either under ice and snow or under an ice-covered ocean. According to Croll this period would appear to have lasted for more than 150,000 years. I have ventured on an approximate estimate of 15,000 to 25,000 years, though it must be admitted that the data for this are still very insufficient. For us, however, the important question at present is to understand that anyhow the time needed for the advance and retreat of the great ice streams must have been long; and it is this which gives the measure of the interval between the Plateau and the Palæolithic races of men. A very considerable length of time must also have been needed for the evolution of the symmetrical forms of the valley drift implements from the rude plateau types, a transition greater than that which separates the work of the valley from that of the stone period artificers.

No traces of older man have been met with on our land; and though elsewhere instances have been recorded they have either proved mistaken or else require confirmation. Of one thing I feel satisfied, which is, that in no other instance do the phenomena exhibit so well as in this part of Kent the successive geological stages bearing upon the human occupation of the land, and so clearly help to establish the "Greater Antiquity" of early man. JOSEPH PRESTWICH.

PSYCHOLOGY.‡

By E. B. TITCHENER.

PSYCHOLOGY, as we all know, is the "science of mind." But such a definition does little more than raise the question, What is mind? We cannot take mind for granted, for it is the very thing that psychology has to investigate. And yet, although "mind" is one of those words which it is impossible to define, every one is able to attach some sort of meaning to it. What do you yourselves mean when you talk of your "mind"? You mean, probably, some particular group or set of your internal experiences; some tangle or other of feelings, thoughts, desires, resolutions, ideas, wishes, hopes, actions, emotions, impulses, expectations, memories. There are plenty of words expressing different "sides" of mind, as they are called. Mind, then, is the sum total of all these experiences—of all these processes. There is no mind beyond them; the term is simply the collective name of all such processes as those which I have enumerated.

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† Our observations apply only to the geology of the Quaternary period.

‡ A lecture delivered to the Class in General Philosophy (Introductory) in Cornell University, December, 1894.—Science.

I said, however, that when you talk, in an everyday way, of your "mind," you probably refer to some special set or group of these experiences. When you say, "I cannot make up my mind whether to do it or not," you mean that you cannot make up your present mind. Now here the psychologist makes a distinction. We use the term "consciousness" to express the mind of the present moment. Thus if I were to ask you to tell me something of your experiences just now, I should say to you: "Look into your consciousness, and see whether so and so is taking place or not." Or, again, if I were to analyze for you your present state of mind—to try and imagine what is going on inside of you as you listen to me—I should speak technically of analyzing your consciousness. Consciousness is the mind at any moment. Mind, therefore, is the sum total of consciousness experienced in the lifetime of the individual. You have one mind, extending (I hope) over seventy full years; but the mind upon which you experiment at any given moment for psychological purposes—or the mind which you make up at a given moment—is called your consciousness. So that psychology, while it is the science of mind, in the sense that it deals with all the mental experiences of a man, from the time of his birth to the time of his death, deals in any special hour, during any special inquiry, with the phenomena of consciousness.

But consciousness—as the number of words in my catalogue of a moment ago sufficiently indicated—is a very intricate, complex and tangled matter. If we are to examine it at all carefully, we must try first of all to get some sort of order into its phenomena. Let us begin the attempt at once of describing our internal experiences, as accurately as possible.

We notice, at the outset, that we are to a large extent at the mercy of our surroundings, of things outside of us. We are not free to see what we like, to hear what we like, to touch what we like; what we see and hear and touch is all determined for us, by the physical nature of the bodies from which impressions come. You can understand, of course, that this is true in the simple instances that I have given; but I want to prove to you that it is true of a very large part, indeed, of our mental experience. Put down in the first place (1) sensations and perceptions. Every time that one of our sense organs is excited, is put in action, that is done by means of something in the external world. An ether vibration makes us see; an air vibration makes us hear or smell, and so on. Those are sensations. And perceptions only differ from sensations in being more complicated. Thus in the sphere of sight, you perceive a house or a tree; in the sphere of hearing you perceive a musical harmony or a musical discord; in the sphere of touch you perceive that a complex of impressions is a piece of wood, or a piece of wire, or what not. The tree and the house are compound impressions, containing many colors and many shapes; the musical chord is a compound of three or four or more simple tones, and so on. All this, very obviously, comes from the outside world. So, too, does (2) memory. You cannot remember what has not happened. If you try to remember a name, you try to recover a lost perception—the perception of the spoken word. If you try to remember a picture, you are attempting to recover a lost visual perception. It is for this reason that the psychologist distinguishes kinds or types of memory—the visual, the auditory and the motor. People who can play chess blindfold have the visual memory very highly developed. They do not, perhaps, see every piece in their mind's eye, but they see the board as a whole, and know where each piece upon it is. Most "extempore" speakers, too, rely upon their visual memory. There is comparatively little true extempore speaking done. Of course if a man is thoroughly familiar with his subject, or is speaking under the influence of strong emotion, he may be able to address an audience without preparation. But most of us who speak "without notes" do so by the aid of our visual memory; we see what we have written, mentally, paragraph by paragraph, and when our eyes are on our hearers, are really reading from a memory manuscript. Instances of good auditory memory, again, are furnished by those fortunate persons who can recall accurately the airs of an opera that they have only once heard. And people who play the piano "by ear," play by finger memory; their memories are muscular or motor. All these memories, then, depend upon the external world. So (3) does imagination. Imagination can put perceptions together in new or unusual ways; but it can never make a new perception. Try to imagine a color which is different from all the colors that are known. You cannot do it. You may imagine mixtures of colors, hues and tints obtained from combinations of the known colors, which you have never actually seen; but you cannot imagine a new color. The same fact comes out in works of fiction. When Baron Munchausen takes you to the moon or the dog star, and shows you their inhabitants; and when Peter Wilkins describes to you the population of the South Pole—these people are simply human beings, with their characters changed and modified in various ways. They can take their eyes out of their heads and pass them round to their neighbors, or they have wings which fold around them and serve as clothing; but there is nothing new in all this. It is only the putting of the perceptions together that is new, not the perceptions themselves. And the same is true of all the constructions of the imagination, as they are called, devils, centaurs, sea serpents, dragons, hippogriffs, ghosts and the rest of them.

The world outside of us, then, is responsible for a good deal of our mental furniture. We can simplify matters, here, for purposes of classification, by grouping together sensation, perception, memory image and imaginary representation, as "ideas." Sensation is the raw material from which ideas are built up. As for the other usages: if you cannot remember, you say, "I haven't any idea of what that man's name was;" and if you are endeavoring to imagine a circumstance, you say, "I haven't any idea of how that could have happened."

So much for the first principal category of mental

experience. Now in the second place, we are in some respects not at the mercy of the world outside, but the world is at our mercy. What is the great difference between the animal and the plant? Surely this, that the animal can move at will, while the plant is stationary. That seems to be a very simple matter; but just consider how much it means. If the plant is going to lead a stationary life, it can take advantage of the fact—I speak metaphorically, of course—to be careless of its shape and size; or rather, it must make itself as big and as complicated as it can in order to secure all the nourishment possible from one settled spot. The result is that the plant carries its lungs and its digestive apparatus all over it, on the outside. You know the functions of leaves and roots. With the animal the reverse is the case. It is going to move about. It can seek food in different places. The best thing for it, therefore, is to have its lungs and digestive organs packed away inside of it; so that it can get about with as light a weight to carry, and as convenient a balance of that weight, as possible. There must be no loose ends left on the outside, injury to which would mean inefficiency or death. Well! You see that by moving among things at its own will and pleasure the animal has a certain power over the external world. How is this power represented in consciousness? In two principal ways: (1) Whenever we move; or, to put the matter more technically, and more definitely with reference to ourselves as distinct from the lower animals, whenever we act, we have in consciousness the experience of effort, of endeavor. This is an experience quite different from the experience that comes to us as ideas. We can have, naturally, an idea of effort; that would be the idea of some person making the effort, or the idea of some obstacle to be overcome by effort, or what not. But besides the idea of effort, we experience effort itself. That is one of the hardest points in psychology to have made clear to you, or to make clear to yourselves. This instance may help you: You know that we speak of one man as having more "go" in him than his neighbor, without implying by the phrase that he has more ideas. There are many names for the effort experience. Some psychologists speak of it as the experience of spontaneity, of one's own initiative; others of an activity in consciousness. "Effort" is at once the most concrete and, I think, the most intelligible word. (2) Our power over the world outside, again, is manifested in another way—by the phenomena of attention. Not every process among our physical surroundings has us at its mercy in the same degree. We are exposed to all manner of impressions; but they are not all alike powerful to affect our consciousness. Think of your own state of mind now. You have presented to you a certain number of visual impressions—the room, its furniture, the people about you. You are subject to certain temperature sensations; to certain pressures, from your clothing; to certain organic sensations, hunger or satiety. Each of you has a large stock of memories, ready to crowd into consciousness if they are allowed to. Each of you, again, has the day's programme in his mind; he can imagine what will be done between now and bed time; and this train of ideas of the imagination is ready to sweep across his mind, if free play is given to it. But all this medley of conflicting influences you are able, if you like, to neglect. You can just brush them aside, by attending to the single series of auditory impressions that is affecting you, to the succession of words which I am speaking. When the whole of your surroundings is pressing in upon you through the avenues of the sense organs, clamoring for notice, you have the power of choosing which shall be let in at the door of consciousness. Only those facts cross the threshold to which you desire to attend.

"But," you may say, "suppose that this is true, what has attention to do with movement? You told us that it was movement that distinguished the animal from the plant, and that along with movement went power over the external world. Now what has movement to do with attention?" That is a perfectly fair question, but one which I cannot here answer for you in detail. To understand the fact of the connection thoroughly—and the connection is a fact—you must have studied psychology. But I can give you a pair of statements which will be better than nothing. The first is this: Whenever we attend, we move. I do not mean that the whole body moves, that there is locomotion, but that there is movement—movement in the eye, movement in the ear, movement in the scalp, movement somewhere. And the second is this: It is the moving thing that attracts the attention. You cannot attend to one single thing, one really single thing, for more than a few seconds together. Either you go to sleep, or you go into hysterics. On the other hand, one is almost constrained to attend to anything that moves. You can hear the single voice that carries the melody, when there is an orchestra of half a hundred instruments thundering on at the same time, because the melody changes, the tones move; while the accompaniment is relatively stationary. So that attention to the melody is easy. If any of you have been out shooting after dark, you will know that one tells the game by its movement. So long as it is still, it is safe. But let it move, and though the eyes have been looking in a quite wrong direction, the attention is drawn upon it by force, as it were; one cannot help seeing it.

Those, then, are two categories of mental experience. There is one more to mention. This self of ours, this "I," which is exposed to the physical changes in the world in part, and in part helps to bring about physical changes in the world by moving to and fro in it, is not indifferent to what goes on in either case. It does not just have ideas, on the one hand; and attend to them or move in consequence of them, on the other. It does more; it feels. It feels when impressions come in; it feels when efforts go out. So that alongside of ideas and efforts must come a third category of mental experience—feelings. Feeling is of two kinds, pleasurable and painful. It is quite distinct in consciousness from ideation, and from effort and attention. That is another of the points which arise at the very beginnings of a study of psychology that it is extremely difficult to get clear about—that pleasure and pain, as such, belong to an entirely different order of processes from the processes which we call collectively ideas. But it is a fact, despite the intimate interconnection of the two in our concrete experience. Let me try to drive it home for you by two illustrations. You cannot remember a pleasure or pain. When you try to recall the pain of a flogging that you had at school, what you recall is really only the complex of perceptions, not the pain itself. You remember all the circumstances—your being sentenced, the people standing round you, the room in which the fatal event took place, the master who did the deed. All these are ideas. But so far are you from being able to remember the actual pain of the flogging that the memory of the circumstances to-day may be actually pleasant; you smile as you look back on them. That is the first illustration; the second is this: You cannot attend to a pleasure or pain as such. It is a common saying that if you attend to a toothache, for instance, you "make it worse." That is bad psychology. You attend, in reality, to the tooth. That means that you perceive the tooth more clearly than anything else for the time being; your idea of the tooth is the very strongest in consciousness. But by attending to the idea and so making it clearer, the feeling that goes along with the idea is made clearer, too. So the pain "gets worse," not because you attended to it, but because you attended to the group of perceptions with which it was connected.

Now, then, we have got our raw material into something like order. Consciousness, instead of being a shapeless tangle and maze of various intertwined and interwoven processes—as it appeared to us to be when we started out on our inquiry—has proved to be capable of arrangement and simplification. You may, it is true, raise the objection that our table of contents is, perhaps, not inclusive of every known mental state. Where, you may ask, is emotion; where is expectation; where are all the rest of the familiar terms for mental experiences? Well, you must take my word for it, that all these other states of mind or mental experiences can be derived from the three simple processes which I have named to you. If you were to work through a psychology, you would find that there was nothing treated of, in any chapter of it, which was not a compound of these three sets of elements—ideas, feelings and efforts—mixed in different proportions. And that being the case, it is these three elements with which psychology begins. She first of all describes them, as minutely and accurately as possible, and then furnishes a theory or an explanation of them, in the sense that she gives the conditions, bodily and mental, of their appearance in consciousness. Under what conditions do we have this and this perception? Under what conditions do we remember and imagine? Under what conditions do we feel so and so, attend to this and that? These are the questions that come up for answer.

Into those questions we cannot here enter. Let it be sufficient for you, in this lecture, to have learned the names and characters of the simplest items of mental experience—of those items which are always and invariably present in our concrete, everyday experiences. Draw for yourselves an outline map of mind. You must make three countries, as it were, within that map. Ideas must go in in one color to the right; efforts in another to the left; and feelings will lie in the middle between the two. And you must suppose that each of these three territories has an independent government; but that their governments are very friendly, and often take joint action—indeed, that they hardly ever think of taking action of themselves. Especially must you conceive that both idea and effort have right of way through any part of the dominion of feeling; and that the communications are so open, and the relations so close, that scarcely anything can affect idea or effort, from the outside or from the inside, that does not also exert an effect upon feeling. The detailed survey of the three territories, and the laying down of roads through them for the student to follow—that is the further business of psychology.

A NOOK IN THE GREAT BARRIER, SEEN AT LOW TIDE

THE BARRIER REEF OF AUSTRALIA.

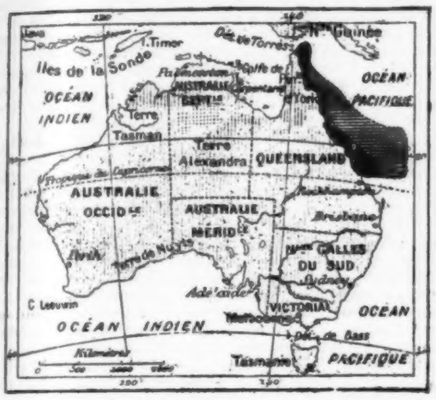
ALL along the northern coast of Queensland, that is to say, for a length of more than 1,100 miles, we meet with a large number of reefs formed exclusively of corals, which collectively constitute the Great Barrier of Australia. These breakers, which were first discovered by Cook, have been scarcely known, except from the difficulty, and even the impossibility, of navigating them, experienced by mariners. Fortunately for naturalists and geographers, the government of Queensland, desirous of knowing this living barrier, which almost wholly shuts off access to it from the sea, and of finding out what resources it might be capable of yielding, had it explored by that very distinguished geologist, Mr. Saville Kent. The latter has surveyed the reef in every direction for several years and obtained results that are very interesting, not only from a scientific, but also from an economic view point.

The great reef begins at Torres Strait and extends as far as to Lady Elliot Island, its distance from the coast varying between nine and ninety miles. It is a true wall, which, rising from the bottom, where it is formed of dead polyps, comes flush with the surface of the sea, where it is formed of living madreporaria. But the breaches in this wall are numerous, and

twenty-two of them even permit of the passage of ships of quite large tonnage. At the period of high tide, nearly the entire archipelago disappears under a thin sheet of water, but at low tide the polypi nearest the surface appear in the air and form vast spaces that often extend beyond the range of vision.

Between the coast and the reef, however, there always remains a free space that occupies a superficies of no less than one million square feet, and where the sea is almost absolutely calm. On the contrary, upon the entire eastern edge of the reef, the sea is constantly agitated and breaks into foam thereupon.

The great majority of the organisms that form the reef are corals, those ramified shrub-like objects of irregular form and stony consistency that every one has seen in museums of natural history or in the bazars of seaside cities. By the fineness of their calcareous tissue and by the often regular designs that



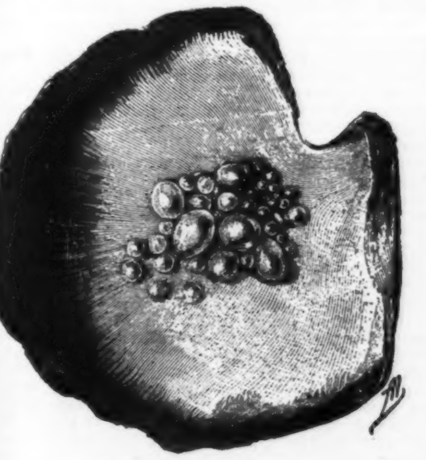
MAP OF AUSTRALIA, SHOWING THE POSITION OF THE GREAT BARRIER.

ornament them, the specimens brought to France are of so rare elegance as to cause a demand for them for etagère or mantel ornaments.

But how much prettier still are these corals in their native state! Covered with small polyps, having elegantly dissected tentacles and exhibiting tints that are varied to infinity, they form genuine shrubbery bearing animate flowers that give the reefs the aspect of the most beautiful garden plots. There are red, blue, green, lilac and yellow ones, and those of other colors still. Some exhibit to us crude tints that recall the simple paintings of the Chinese; others have rainbow reflections, and others still—a sort of Loie Fullers—possess chatoyant tints that vary with the incidence under which they are observed and the intensity of the light that strikes them. And what shall we say of their forms? To cite all of them is something not to be thought of. Let us, however, mention the most frequent: The symphyllies, capable of reaching several feet in diameter, are covered with complicated meanders; the goniasters resemble human crania; the pocillipores are shaped like a cauliflower; the fungias recall huge stipeless toadstools, with gills borne upon the upper surface; the lophoseres are arranged in vertical leaves, and the madrepores resemble ramified and tufted bushes.

All this forms colonies, each of which comprises myriads of individuals. Continuously destroyed at the base, they are constantly renewed at the summit. The detached polyps form a new colony. Far from being fond of a calm, they seek a tempest, and the billow that breaks them merely increases their number and their vitality. The solid part of the mass is, besides, formed of algæ, which, far from possessing the habitual softness of such plants, are incrusted with lime, and, in their hardness and aspect, simulate true polyps.

Amid these madreporia and these algæ that constitute the greater part of the reef, there exists an ex-

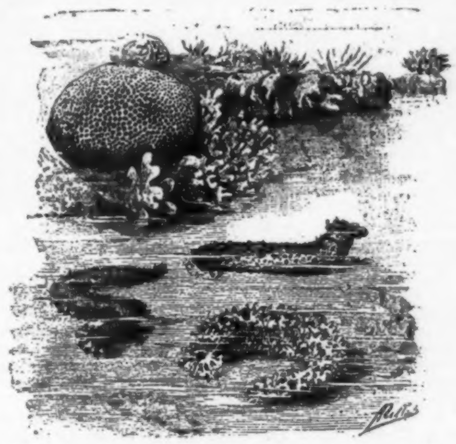


PEARL OYSTER.

traordinarily rich and varied fauna. There are here sea anemones of gigantic size, gelatinous alcyonarias, odd mollusks, transparent crustaceans, fantastic holothurians, sea urchins with huge spines, fishes with curiously mottled sides, etc. All this little world lives, moves and reproduces itself and dies in always leaving a part of itself upon the reef, to the building up and solidification of which it contributes to a slight degree. How many interesting facts are still to be gleaned in this terrestrial paradise of the naturalist!

Mr. Saville Kent is a very broad-minded man. Despite his love for pure science, he has not neglected the practical side of his mission. In this order of ideas he has reached very fine results. The Great Barrier Reef, in fact, gives rise to three industries—the pearl and trepang fisheries and oyster culture.

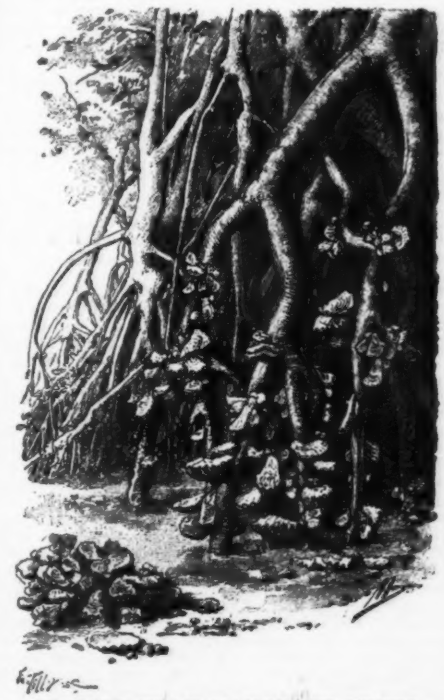
The pearl oyster industry, the headquarters of which are on Thursday Island in Torres Strait, yields a revenue of $350,000 a year. The oysters live at a depth of seven or eight fathoms. They are collected by divers from the bottom of the sea, where they lie free or are attached by a few horny filaments after the manner of mussels. The master of the boat deals especially in the mother-of-pearl of the shells, the pearls being relatively rare. Sometimes, however, very beautiful specimens are met with, as shown in one of our figures, which represents an oyster containing pearls of different sizes. The difficulty of fishing for the pearl oyster decided Mr. Kent to try artificial cul-



HOLOTHURIANS SWIMMING IN A POOL.

ture. The experiments are not yet decisive, but everything leads to the hope that they will soon be crowned with success. They have shown, in fact, that, contrary to the opinion of the fishermen who consider the pearl oyster as a migratory animal, the mollusk is sedentary or at least does not move about much. They have shown, too, that these shellfish can be quite easily transported and will live in shallow water. It is to be hoped that the pearl oyster culture will soon prove a source of wealth for the Australians. We know, in fact, that it is possible to cause the oysters to produce pearls artificially through the introduction, between the body of the animal and its shell, of grains of sand or of various objects, which become gradually surrounded with nacre and thus change into so many fine pearls.

The trepangs give rise to a very large trade with the Chinese, who consume great quantities of them. These are holothurians of various species resembling cucumbers, and some of which are three feet in length! These animals, known also as sea cucumbers, with a serpentiform body of glutinous aspect and covered with singular appendages, crawl slowly over the surface of the madrepores in pools of water. They are collected by hand at low tide. When they live at a greater depth, the fishermen capture them from their boats by means of a trident. As soon as they are cap-



OYSTERS UPON MANGROVE TREES.

tured they are boiled and then eviscerated. They are afterward dried in the smoke of the wood of a species of Rhizophora, until they are of a very hard consistence. In this state they resemble black dried sausages, and are ready for shipment to the Chinese, who pay a high price for them and use them for making soups and various other dishes. It seems that the Australians are likewise acquiring a taste for them, and trepang soup may soon become the national dish of Queensland, as is the "bouilla-baisse" at Marseilles.

Edible oysters live scarcely anywhere else than along the coast, and particularly in the vicinity of the large estuaries. They prefer brackish water containing equal parts of sea water and fresh water. They form immense banks in the mud of the swamps ending at the sea, and it is only necessary, so to speak, to stoop in order to gather them. It is a curious fact that they may be seen upon the roots and branches of the mangroves that grow along the coast, and this formerly gave rise to the legend of trees that bore oysters instead of fruit. It is useless to say that these mangroves are bathed by the water at high tide, or at least receive a sufficient supply of sea water to support the life of the mollusks.

The work which we have just summed up in its general features shows what interest attaches to a knowledge of the Great Barrier Reef. Mr. Kent proposes to establish a maritime laboratory there for a profounder study of it. This is an excellent idea, for which we applaud him.—L'Illustration.

TRILOBITES.

THE recent admirable work of Prof. C. E. Beecher at Yale on the trilobites is a continuation of those most valuable researches which have been undertaken at the museum in New Haven under the direction of Prof. O. C. Marsh. The work of Prof. Beecher is particularly interesting, the more so since what he is securing is indeed news about a very old family.

The trilobites were very numerous inhabitants of the waters in past geologic ages, of which it has been supposed that no near relative survives. Through our country they are to be found in quantities in New York, Ohio and other limestone States, and are very frequently found curled up in little rounded balls, strongly marked by the two deep grooves which give the fossils their three-lobed appearance. For many years the trilobite has been set down in the zoologies as a relative of the horseshoe crab so common along our shores, but through Prof. Beecher's investigations a somewhat different place in nature has been assigned to this prolific crustacean.

The basis of the discoveries has been the finding of a new set of fossils in a new locality in New York State. A fossil is preserved to us through the substitution of mineral matter for the tissues of the once living animal, and this substituting material may be very different in its constitution. Sometimes lime replaces the animal tissues, sometimes silica or flint, and sometimes iron pyrites. As these materials are different, so the process of replacement is different in its nature, being for some materials more delicate than for others, and the pyrites replacement may be termed a replacement in a very delicate and gentle manner. For this reason, in the new series of fossils, the process having been a gentle one, the more delicate portions of the anatomy have been preserved and may now be studied.

It has been discovered in this way that the trilobite had antennæ, and quite a complicated system of legs. So complicated is this system that patience has been a very necessary element in the investigation. Even the inspection of the legs in a recent specimen of allied nature is impossible without an actual manipulation of these members to determine their position and the nature of the portion of the body which they conceal. In the fossils, similar information can be gathered only by the examination of numerous specimens which cannot always be furnished, or by the gentle cutting away of the exposed portions of the fossils, always a difficult and delicate process.

The appendages or legs which Dr. Beecher has discovered are double in their use to the animal, being composed of two parts, one a blade for swimming purposes and the other a toe upon which to walk. This mechanism and other technical features point to a position for the trilobites altogether different from that heretofore assigned to them, and they may now be considered as allied to the copepods, a crustacean of which there is a number of living species.

The fact that anything so delicate in its nature as the antennæ could have been preserved is an encouragement to investigators, for it is now thought that the process which did not destroy these members may have left practically undisturbed the internal tissues, and if so, these may be examined and the nature and position of the trilobites be accurately established.

Since his discovery of legs and antennæ, Prof. Beecher has been very active in his investigations of the structure of trilobites and their embryology. In these matters he has issued a number of technical papers in the American Geologist and elsewhere. It may seem a curious matter to attempt to study at this late day the development of a family which is to-day extinct, but the remains of this ancient race furnish a very large proportion of the younger forms, thousands of them, and the difficulty is rather to secure a sufficient number of the adults which have not curled up at their death, to render a study of their lower side and its appendages possible.

Prof. Beecher's work brings to mind the position which Yale has ever held under Prof. Marsh in the study of fossil forms. The prolific Western beds, which have made such wonderful yields within the past few years, have been studied here, and the restoration of the enormous and eccentric animals which once roamed over our country has been largely done within the walls of this museum.

The great Brontops, an enormous two-horned rhinoceros, which nearly equaled in size the elephant of to-day, was found in its most perfect representatives by Prof. Marsh in his investigations in Dakota, some twenty years since. Triceratops, the great horned lizard, twenty-five or thirty feet long and ten in height; Brontosaurus, another of the Dinosaurs, a herbivorous reptile walking on four feet, with long outstretched neck and dragging tail, a vegetarian of sixty feet in length and thirty in height, with a probable weight of more than twenty tons—such specimens as these it has been the work of the Yale museum to investigate and publish to the world; and here, in the capacious storehouses, are the bones of these great animals, so enormous that they cannot find place in the present exhibition rooms.

The releasing of these specimens from their inclosing matrices of stone is an interesting process. They do not fall out as does the meat of a walnut, merely at a tap of the hammer. On the contrary, they are solidly inclosed in stone, and it is no small part of the geologist's work to laboriously chip away the mass of rock. It reminds one of Hawthorne's idea of a statue being imprisoned within the marble block, and that the work of the sculptor is merely to free it. Slowly

and carefully the stone must be cut away, always tenderly, for the material of the fossil may be much more delicate than the matrix. With the smaller fossils, the work demands the greatest skill, and the rotary drills of the dentist and his other delicate tools find no small portion of their utility to be in the hands of the geologist in releasing the remains of organic life of long ago. As with the astronomer, the popular opinion of whom is that he spends his time peeping through a telescope, while in truth the telescope is hardly more than an incident in his life, so with the geologist, he does not spend his time in roaming the fields in search of specimens, but on the contrary, the largest part of his work must be in the laboratory, studying with great care, for months and even years, what has been secured for him by a few days' work of collection in the field.—Boston Commonwealth.

PRECIOUS STONES, AND HOW TO DISTINGUISH THEM.*

AMONG the duties which fall to the lot of an official in the mineral department of the British Museum, in his otherwise unromantic and sternly studious life, is one which is not altogether devoid of human interest. It may happen, for example, that a lady having inherited a priceless heirloom in the shape of a large emerald, travels from the Antipodes in order to sell it in England for its true value, and desiring to display its charms, brings it to the museum. To inform such a person that the stone is but green bottle glass cannot be a pleasant task.

Only within the last few months came an Afghan prince who had sold his worldly goods, traveled to the coast of India and worked his passage to England, having secreted about his person a stone which he supposed to be of enormous value. His story was that, as he slept upon the hillside, Mahomet had appeared to him and told him that he would find a rare jewel under his hand. The poor man could not be convinced that a stone with this celestial guarantee could be anything common; for, as he said, "Mahomet cannot lie." Be this as it may, the stone was quartz, and its princely owner could only be advised to repair his fallen fortunes in some Oriental fashion at Constantinople—Kensington.

It is curious that the stones brought by such people are always, in the opinion of their owners, gems of the greatest value and rarity. Could they but have consulted some competent expert nearer home, they would have been saved time and money and bitter disappointment.

But after such interviews, I have always been very forcibly impressed by the fact that even the experts do not seem in the least aware of the simple and certain methods which have been placed at their disposal by recent mineralogical research. There is, perhaps, no subject in which experts have been so slow to take advantage of practical methods supplied by science as in the manipulation and discrimination of precious stones.

The stones brought by these chance visitors have often been bought and sold over and over again under totally false names. There is, I suspect, scarcely a collection, public or private, in which some of the jewels are not wrongly described.

Mistakes are constantly made; and these are sometimes of considerable commercial importance. It may be remembered, for example, that a few years ago much excitement was caused by the discovery of rubies in the Macdonell Range in Southern Australia. Much time and money was wasted in their extraction before it was discovered that, like the so-called Cape rubies, they were merely garnets.

I should be the last person to underrate the great value of that knowledge which results from long experience, or to deny that in ninety-nine cases out of a hundred an expert may be absolutely right. Every one must admire the confidence with which a practiced eye can even pick out from several packets of diamonds those which came from a certain mine.

Such a professional expert may in five seconds pronounce a judgment which it might require half an hour to establish by scientific methods and one which may be equally correct.

But there is a vast difference between "may be" and "is," and scientific men are not satisfied with that sort of judgment, but require actual proof.

One ought to distinguish between two sorts of expert knowledge—that which results from long experience and the training of eye and hand and that which results from familiarity with scientific methods. To have confidence in the non-scientific expert, one must place reliance upon his personal character and the soundness of his senses, and be sure that his actual experience has included problems similar to the one submitted to him, and even then he may fail in that hundredth case.

But the scientific tests cannot err; moreover, they furnish a proof which carries conviction to all who see it. The opinion of the expert need convince none but himself.

An exact parallel is to be found in medical practice. It is no doubt often possible for a doctor of experience to diagnose diphtheria and phthisis by their symptoms. But in recent years new methods have been made available by the discoveries relating to bacteria, and at the present time no diagnosis of diphtheria or of the early stages of consumption would be considered complete which did not include the bacteriological evidence; that is to say, the isolation and microscopic examination in each case of the specific bacillus. What is more, such evidence is proof positive of the existence of the disease.

Now the only characters at all generally employed by persons connected with the trade in precious stones are two—namely, the hardness and the specific gravity or weightiness.

If a stone scratches quartz and is scratched by topaz, it is said to have a hardness between that of quartz and that of topaz; if it scratches topaz but is scratched by sapphire, it is said to have a hardness between that of topaz and that of sapphire. All minerals, including the gem stones, have been tabulated according to their hardness with reference to ten standard stones, of which the diamond, the hardest of all known substances, heads the list. If, for example, a red stone, supposed to be a ruby, is found to be only about as hard as topaz, it cannot be a true ruby, but must be a spinel ruby, which is quite a different thing; or if it is sufficiently soft to be scratched by rock crystal, it is probably a red garnet.

This test is obviously a very rude one in more senses than one. Not only does everything depend upon the nature of the scratching part, whether it is a sharp corner or a curved surface, and upon the direction in which the scratch is made; but, to say the least, the surface of a gem is certainly not improved by scratching.

The second test—that of the weightiness—is a really accurate and scientific one, provided that it be made by means of a delicate chemical balance. A stone which is, bulk for bulk, three times as heavy as water, is said to have a specific gravity of 3; one such as topaz, which is three and a half times as heavy as water, is said to have a specific gravity of 3·5. The ordinary method is to weigh the stone, suspended by a thread, first in air and then immersed in water. The difference is exactly the weight of the water displaced by the stone, and so the specific gravity is easily found.

The objections to this method are, first, that it is too laborious; and secondly, that it is not applicable when the stone is very small, because it is then impossible to weigh it with accuracy under water. I should not rely upon the specific gravity of a stone under two carats in weight as determined by this method. A method which I shall presently describe is perfectly free from both these objections.

Incredible as it may seem, the estimation of hardness and the specific gravity are the only attempts at anything like scientific measurement ever made in the ordinary course of business applied to stones; and even then the weightiness is usually estimated merely by poising the stone in the hand. For the rest they are identified by their color, their fire or sparkle, their luster and their general appearance.

In a lecture delivered to the Society of Arts in 1881, Prof. Church drew attention to the necessity of scientific methods for this purpose, and has more than once, on subsequent occasions, reiterated his plea. I propose to dwell more particularly on improvements which have been introduced since the date of his lecture, and to indicate how one may, by simple practical tests, which require little special knowledge, distinguish with certainty all gem stones without in any way injuring them.

Chemical analysis is, by the very nature of the problem, out of the question, for in order to make an analysis or to apply the simplest chemical test, it is necessary to destroy a part of the material; and this cannot be done, at any rate, in the case of a cut stone.

We can begin by dismissing the hardness as a character which it is really unnecessary to determine, except to identify diamond or to distinguish a real stone from paste; here, I know, I shall earn a rebuke from the orthodox mineralogist, who, in order to pursue the study of what should be a peaceful science, arms himself with a knife and proceeds to scratch everything which he comes across.

The weapons which I would recommend are of a milder nature: the microscope, the spectroscope, the goniometer and the dichroscope.

Among the available characters of gems, first and foremost, are the optical properties; that is to say, the appearances seen when we look at them or through them in various ways.

The extent to which a ray of light is refracted on entering and leaving a transparent stone is a characteristic property most useful for determination. As every one knows, a stick half immersed in water appears bent, owing to the refraction of light on passing out of the water; if it is immersed in a more highly refractive liquid, it appears more bent.

To ascertain the refractive power of any transparent substance like glass, a prism-shaped piece is cut from it, and the extent to which a ray of light is refracted on passing through the prism is measured by the goniometer, an instrument found in every physical laboratory.

I have not seen this recommended as a method to be practically used, because it is commonly supposed that a special prism must be cut from the stone for the purpose. For the benefit of those who possess a goniometer, I may say that it is a method which I constantly apply and find most useful for unmounted cut stones. It is always possible to find two of the facets which form a convenient angle, and, after inking over the remainder of the stone to trace the ray passing through these two facets, and so to measure with absolute accuracy not only the refraction, but the double refraction of the stone; moreover, this method is applicable to any stone, however great its refractive power.

Another simple plan which can be used by any one, but unfortunately only for stones of comparatively low refractive power, has been invented during the last few years. This delightfully simple little instrument, known as the reflectometer, consists of a hemispherical glass lens viewed by an eyepiece containing a graduated scale; it need only be pressed against the plane surface of a cut stone previously touched with a drop of liquid of higher refractive power than the stone itself. On looking into the eyepiece a shade is seen over half the field of view, and its edge crosses the scale at a point which gives the exact refractive index of the stone. The best available liquid is monobromo naphthalene, which has a refractive power higher than that of topaz, and enables one at a glance to distinguish a cut topaz or any less brilliant gem stone.

Most useful, again, are the so-called interference figures—the appearances seen on looking through a transparent stone by means of a polarizing microscope, such as is used by every geologist. There is, of course, nothing new in these figures; they are now employed by geologists in the study of rocks, and even sometimes by those whose business it is to distinguish precious stones.

Without endeavoring to explain the nature of these figures, except to say that they are due to the double refraction of the crystal, it is easy to show that by looking at a stone through a microscope, one may see something very characteristic.

(The interference figures of several minerals were thrown upon the screen by means of a projection apparatus lent by Prof. Ayrton; sapphire, tourmaline and emerald were shown to give colored circular rings intersected by a black cross; sphene and chrysoberyl, colored oval rings intersected by a hyperbola; and quartz, colored circular rings with a black cross having a tinted center.)

This beautiful method is not employed nearly so largely as it deserves, because most people find it difficult. In order to see the figure it is necessary to look through any given crystal in one certain direction. (The stones used for projection were plates appropriately cut for the purpose.) Now it may happen that a faceted stone is so cut that to look along the required direction would be to look through an angular corner; and every one knows that it is not possible to look through a pointed corner, owing to the refraction of the light. For this reason, when an unmounted cut jewel is held under the polarizing microscope and yields no interference figure when turned about into various positions, it is usually given up as hopeless. But obviously we have only to immerse the stone in some liquid having nearly the same refractive power as itself, in order to eliminate the difficulty due to refraction. I find that if the stone be placed in a small tube filled with oil or glycerine and held in various positions, the interference figure can always be seen. Little more than a year ago, a small faceted stone of peculiar appearance was sent to me, which had deceived the experts to whom it had been shown, although agreeing in some respects with quartz, and was supposed to be a new stone. But by immersing it in oil in a hollow glass sphere, I was able to see the characteristic interference figure of quartz. When a stone has the refraction, the double refraction, the specific gravity and the characteristic interference figure of quartz—it is quartz and nothing else.

Other optical characters of great value are those resulting from the absorption of the light in its passage through a crystal; some of the colors contained in ordinary daylight are more absorbed than others, and the light emerges more or less colored; in consequence of differences of absorption, some gem stones appear differently colored, according to the direction in which one looks through them. I need not dwell upon this curious property, because the instrument used to observe it is the one piece of scientific apparatus sometimes, but by no means generally, used by gem experts—I mean the instrument known as the dichroscope. (A diagram, kindly lent by Prof. Judd, illustrated the appearance seen with this instrument.) Far less familiar is the method of studying the absorption by means of the spectroscope, although the value of this extremely simple method was pointed out many years ago by Prof. Church. Every one knows the colors of the spectrum seen by daylight through a glass prism, and it is also well known that if light transmitted through various vapors be appropriately observed through such a prism by means of the spectroscope, certain black lines are seen in the spectrum, indicating that the vapor has absorbed light of a certain color; in this way astronomers are able, by merely looking at the sun and stars, to ascertain many of the elements which they contain.

But it is not commonly known that a precisely similar effect is produced by many transparent minerals. It is only necessary to look through a pocket spectroscope in a bright light at any transparent mineral containing the rare element didymium, and certain black bands characteristic of that element are at once seen in the spectrum.

(A diagram of the spectrum of the phosphorescent light emitted by ruby when made to glow in the electric discharge in a vacuum tube, lent by Prof. Crookes, though not a picture exactly of what is here described, served to illustrate the appearance of the black bands in the spectrum of a red mineral.)

Now, there are two gem stones, which give very characteristic black bands when looked at through a spectroscope, namely, the jargoon or jacynth, and the variety of garnet known as almandine, commonly called carbuncle. When a stone, say one set in a ring, is looked at in this way, and gives the characteristic spectrum of zircon, it is at once known to be a jargoon without further trouble.

When one remembers how many pocket spectroscopes are bought by people who wish to see the rainband and predict the weather, it is surprising that it has not also come into use for the examination of gems.

To pass from optical to other characters, there is a very remarkable property possessed pre-eminently by one mineral which has not, so far as I know, been previously recommended as a practical test.

A crystal of tourmaline while being warmed or cooled becomes electrified; one end becomes charged with positive, the other end with negative electricity. The fact has long been known. But a few years ago an extremely pretty and ingenious way of showing the electrification was devised by Prof. Kundt. If a mixture of powdered red lead and sulphur be shaken or blown through a sieve, the particles become electrified by mutual friction, and if it then be dusted upon a crystal of tourmaline which is being warmed or cooled, the positively electrified end of the crystal attracts the negatively electrified yellow sulphur and the other end attracts the positively electrified red lead; one end of the crystal becomes red and the other end yellow; and so the difference of electrification is made visible. Now every crystal of tourmaline behaves in this way, and I find it perfectly easy to show the property in an ordinary small jewel, even when mounted in a setting. All that is necessary is to warm the stone, and then, while it is cooling, to dust it with the mixture; at once one part of the stone becomes red and another part yellow.

(A faceted stone treated in this way was shown upon the screen by reflected light.)

The last character which I have to mention is the one to which I alluded at the beginning, namely, the heaviness or specific gravity. The use of the balance is, as I said, too laborious; but within the last few years an entirely different method has been introduced.

Cork and wood float in water because, bulk for bulk, they are lighter; stone and iron sink because, bulk for bulk, they are heavier than water. But find some substance whose density is exactly that of water, and it will neither rise nor sink, but will remain poised in the water like a balloon in mid air.

Several liquids have been discovered which are more than three and a half times as dense as water, in which

* A lecture delivered at the Imperial Institute, by Mr. H. A. Miers.—Nature.

therefore amethyst, beryl, and other light stones will actually float. Prof. Church strongly recommended mercuric and potassium iodide; but a still more convenient liquid is now available, namely, methylene iodide. This liquid has a specific gravity of 3·3, so that tourmaline readily floats in it; further, it is not corrosive or in any way dangerous, which is more than can be said for several of the other liquids which have been recommended.

Now it is scarcely possible to prepare a number of liquids, each having the specific gravity of one gem stone, in order to identify each stone, but methylene iodide is easily diluted by adding benzine to it; each drop of benzine added makes the liquid less dense, and so it may be used to separate tourmaline and all the lighter gem stones from each other. Nothing can be easier or more satisfactory than this method; no matter how minute the stone may be, it can be identified by its density in a few moments. Suppose it be doubtful whether a certain gem is aquamarine or chrysoberyl, all that is necessary is to place it in a tube of the liquid, together with a small fragment of true aquamarine to serve as an index; if it be a chrysoberyl, which has a specific gravity of 3·6, it will sink like lead; if it be an aquamarine, which has a specific gravity of 2·7, it will float; and if the liquid be then stirred and diluted until the index fragment is exactly suspended, the gem also will neither float nor sink, but will remain poised beside it.

The delicacy and simplicity of the method is marvelous; the only reason why it has not been more generally adopted is that, unfortunately, the greater number of gem stones are heavier than methylene iodide. What is the use of employing such liquids when they cannot float jargoon, carbuncle, sapphire, ruby, chrysoberyl, spinel, topaz, peridote, and diamond, to mention only those stones whose names are familiar?

But this objection is now entirely removed, thanks to a discovery made quite recently by the distinguished Dutch mineralogist, Retgers. He has found a colorless solid compound which melts, at a temperature far below that of boiling water, to a clear liquid five times as dense as water; and therefore sufficiently dense to float any known precious stone.

This compound is the double nitrate of silver and thallium, and it further possesses a most remarkable property; it will mix in any desired proportion with warm water, so that by dilution the specific gravity may be easily reduced. The fused mass may be reduced in density by adding water drop by drop so as to suspend in succession jargoon, carbuncle, sapphire and ruby, chrysoberyl, and spinel.

This wonderful compound should certainly be employed by all who wish to distinguish gems with ease and certainty.

Let me now remind you how one could apply the methods which I have been describing to identify with absolute certainty some gem stone. Take, for example, a cut tourmaline. Dropped into methylene iodide it would just float, and, when the liquid is diluted, it would remain suspended beside an index fragment of tourmaline, and no other gem stone. Examined with the dichroscope it would show two colored images, indicating remarkable differences of absorption characteristic of tourmaline, and no other mineral; the absence of absorption bands, when it is viewed through the spectroscope, would show that it is neither garnet nor jargoon; in the polarizing microscope it would show the interference figure of tourmaline.

Even if the stone were mounted in a setting so that these tests could not be applied, it could be examined with the reflectometer, the boundary of the shade would cross the scale at a point exactly corresponding to the refractive power of tourmaline; and lastly it could be warmed and dusted with red lead and sulphur, when the two colored patches would betray the electrical properties of tourmaline. There is enough evidence here to satisfy any one but an English jury hearing expert witnesses, and everything can be done without inflicting even a scratch upon the stone.

Another mineral character of great value in distinguishing gem stones in the rough I have not alluded to, because it can only be made use of when they are more or less well crystallized; I mean the shape of the crystals. (This feature was illustrated by some very beautiful photographs of gem stones and other minerals in their natural state, which were taken from specimens in the British Museum by the distinguished photographic expert, Mr. Hepworth.)

It might be asked with some show of reason, why should we require all these scientific tests which I have described, when the varieties of precious stones are so few in number? In reality, however, gem stones are far more numerous than is commonly supposed, although they often pass muster under erroneous names. Tourmaline is sold as ruby, cinnamon stone as jacynth, white jargoon and phenacite as diamond, while green garnets are universally known in the trade as olivine or peridote.

That the varieties of available gem stones are not far more numerous, is due mainly to the prejudice of purchasers, who ring the changes on diamonds, rubies, sapphires, and emeralds, and have heard of nothing else; estimating the stones, as the public estimates popular actors or authors, not by their real excellence, but by their names.

In the mineral gallery of the British Museum are many examples of cut stones which have rarely or never been employed in jewelry, but should certainly win favor on their own merits.

One very curious example is a little gem cut from a crystal of the ordinary tin stone, the same ore which is worked for tin in the Cornish mines. This is a stone which, when cut from a sufficiently transparent crystal, possesses a most beautiful luster and color.

As another example, I may mention a stone which, I suspect from its appearance, would make a very beautiful gem. It was sent with some other fragments from the ruby mines of Burma; it is only a single rough fragment, and has completely puzzled every one to whom I have shown it. By means of the very tests which I have been describing, and without sacrificing more than a pin's point of the stone, I have been able to identify it as the boro-silicate of lime known as Danburite. This mineral, if it has ever been used in jewelry, which is most unlikely, has certainly never been rightly named.

(A number of faceted stones lent by Mr. Gregory, who has made many interesting experiments in this direction, were thrown upon the screen by reflected light; among these were several of the less familiar gems, such as tourmaline, chrysoberyl, phenacite, feldspar, andalusite, axinite, spodumene, sphene, and idocrase.)

I do not know whether the final impression produced by what I have said is that the determination of stones is an easy or a difficult thing. The impression which I wished to convey is that where these scientific tests can be applied, it is an absolutely certain thing, and where they cannot be applied, there is no such certainty.

The crystals from which these gems are cut are changeless and imperishable, their beauty has been enhanced by the art of man, but they have lost none of their wonderful properties in the process; in fact, it is only by utilizing these very properties that the lapidary converts them from dull stones to flashing jewels, and it is by these properties that we have to recognize them.

The ruby formed countless ages ago in the heart of Burma is the same thing in all essentials as the ruby formed to-day in a Paris laboratory.

It is curious to reflect that the diamond which today glitters in a London ball room may have adorned the crown of some Oriental monarch centuries ago—may have been picked from the shores of an Indian stream in the dawn of civilization—may have been the silent witness of the growth and decay of empires—but by its own unchanging existence has always borne steadfast evidence to the everlasting laws of nature.

H. A. MIERS.

THE NOBLEST OF EVERGREEN CLIMBERS.

MR. BURBIDGE wrote to us during the frost from the Botanic Gardens, Trinity College, Dublin, that he had just gathered over sixty varieties of the Ivy. This is a very instructive fact for all who care for beautiful hardy plants. Surely nothing that comes from the tropics or any other country can be more delightful than these Ivies may be made by those who grow and place them well. They are so simply grown that few people ever think of the best ways of placing them so as to get a fair idea of their great beauty.

In many parts of North America and Northern and Central Europe the Ivy is not hardy, and people would give much for the privilege, which we may enjoy, of making really artistic things of these beautiful hardy northern climbers. We know that Ivy generally grows on a wall, and perhaps it cannot grow on anything better; but it is by no means the only use for it. Many people fear Ivy on trees. We should not hesitate to allow Ivy to grow on trees of secondary value, and, if not allowed to overrun the tree entirely, it will not do it much harm. That is only one way. Sunk fences, banks, walls, are all places in which we may plant our Ivies; and another pretty, though very much neglected, way is that of making screens of Ivy instead of the wretched hedges of Privet we often see cutting up gardens. Where a screen is needed, nothing is more beautiful for it than almost any kind of Ivy.

The one most commonly used in that way, and by no means the best, is the Irish Ivy, which is so popular in Continental gardens; but it is better to make a change and use other kinds for this purpose. The screens we speak of are easily formed with trellis work of any kind—iron, stout wire, Oak slabs, or any like material that may be handiest. Planted in fairly rich ground, the Ivies in a few years will cover the screen. Another plan we like very much is that of growing the choicer kinds of Ivy as pyramids, each on a stout prop, the shoots falling down gracefully. Ivy is very charming in all ways. Where there is a large area of dead walls it is a very wise thing to use so valuable a plant for covering them. Why, instead of the thatch and the rotten things we use for bowers and the like, should we not form wigwams and bowers of this delightful evergreen? Construct a stout and simple framework of the desired shape, and in a belt of good soil round the base plant one or more good forms of Ivy, and leave the rest to time.

A roof of Ivy would be very much pleasanter than many things that are used for this purpose, and would not decay in the offensive way common to such thatching material as Heath, straw and Reed. The roof should be well tied together, and an occasional clipping of the ivy will suffice to keep it out of the power of the wind. We are not sure that, with a little patience and care, it could not be made to do for sheltered sheds in pastures, instead of faggots and other rough material commonly used; and where a sheltered shed is placed near a wood, as is very often the case, the body of the shed might be built back into the wood, so as to leave only the front exposed to the field, and in that way we should protect our Ivy from browsing animals.

Another interesting phase of the question is the tree forms of the Ivy, which must not be supposed to be distinct kinds, as the Ivy itself when fully grown and exposed is very apt to take this form. The form we generally see is the Ivy in its creeping state, but when it gets fully developed it breaks out into what we call the tree form, which gives another opportunity to enjoy the variety of aspects of this plant.

All Ivies are good until we come to the wretched variegated kinds, which are not worth growing; collections of these are sure to disappoint; the so-called variegation is only disease, and it is almost as well that it is so, because, if such things grew freely, the effect would be far from beautiful—hard, spotty and unnatural.

Among the more beautiful forms cut on the occasion referred to, without noticing the curious splashed kinds, there are the himalaica or Northern Indian Ivy, a very pretty form; atro purpurea, a leathery looking leaf, and very dark; azorica, a very leathery, vine-like leaf; triloba or tridentata, a handsome arrow shaped leaf; obovata, a very pretty slightly bronzed leaf; palmata, a most graceful Ivy for a tree or wall; H. amurensis, a tall, very vigorous kind; scutata or Shield Ivy; H. Rægneriana, what they call the old Irish Abbey Ivy, an immense Aralia-like leaf, much larger than what is called the Irish Ivy; dentata, a very graceful leaf, massive and leathery too; algeriensis rhomboide, a spoon shaped and very distinct leaf, and so on through a long list, scarcely one of which is not a distinct and valuable climbing shrub.

It would, of course, be possible to make a very delightful garden of these Ivies alone on walls, rocks, or even the ordinary surface of the ground, with groups of Forsythias or Japan Pear, or any other hardy flowering shrubs one might care for among them.—*Field.*

THE POPLARS.

THE following species and varieties of poplars are now in cultivation:

Populus Canadensis or Monolifera (the Canadian or Swiss Poplar).—A well known and easily distinguished species.

P. C. Var. Regenere (or Peuplier Regenere).—This is of a much more branching habit than the type, and grows straighter and more vigorously, attaining in fifteen years as large a size as the type does in twenty years. As a timber tree it is very highly thought of. Being very much in request, some growers have attempted to sell it under various new names, among which we may mention Peuplier Eucalyptus, under which title we have seen it shown at a great exhibition. It is one of the most valuable varieties of poplar.

P. C. Aurea Van Geerti.—A variety with golden colored foliage.

P. Hybrida Berolinensis (the Berlin Poplar).—A hybrid between Populus laurifolia and P. Canadensis, distinguished from the last named species by its more pyramidal habit of growth and its longer and slenderer branches. The leaves also are broader and the roots do not spread so much.

P. Laurifolia Viminalis.—This is not a vigorous growing species, and is not cultivated to any great extent. It is of slow growth, with a low tufted habit and peculiar looking leaves.

P. Certinensis.—An Asiatic species, as yet rare in cultivation. Leaves elongated and glistening, a novel feature in the genus Populus.

P. Fremonti.—A species with elongated leaves, received quite recently from Colorado.

P. Grandidentata.—A North American species with broad, dentate leaves.

P. C. Pendula.—A variety of the preceding with weeping branches.

P. Heterophylla.—Leaves heart shaped. Introduced from N. America, and as yet not generally known by the trade.

P. Simoni.—Foliage very distinct. Introduced from China.

P. Angustifolia.—A small sized tree, with shoots of a light yellowish gray color and lanceolate leaves. Introduced very recently from Colorado.

P. Medusæ.—Introduced from N. America.

P. Eugenii.—A peculiar looking tree, of very rapid growth and pyramidal habit.

P. Tremula (the Aspen or Athenian Poplar).—An indigenous species, growing to a very large size, and owing its specific name to the tremulous motion of its leaves when stirred by the gentlest wind. It grows well in all kinds of soil, and especially so in soils of a light character, sending out its roots to great distances and producing numerous suckers.

P. Tremula Pendula.—A variety of the preceding species, with weeping branches.

P. Alba (the Abele or White Poplar).—A well known indigenous species.

P. Alba Nivea (the White Dutch Poplar).—An improved variety of the preceding species, remarkable for the snow white color of its leaves and bark.

P. Alba Macrophylla.—The leaves of this are broader than those of the preceding variety.

P. Alba Pendula.—A variety of P. alba with weeping branches.

P. Bolleana Pyramidalis.—A remarkable and valuable variety, not much known as yet. A nurseryman of Calvados states that he was the first to receive this from a Russian botanist who was collecting in the Caucasus. Stolen from this nurseryman by one of his employes and sold to a firm at Orleans, it was first sent out by this firm.

P. Caninensis or Canescens.—A species indigenous in Normandy. Leaves like those of P. tremula, but broader, whitish and smooth. Not knowing the scientific name of this species, I had it identified. About ten years ago a small shoot of it chanced to spring up in the heath soil of a plantation of rhododendrons, where I allowed it to remain, and the tree now measures about 14 inches in girth and is a splendid specimen.

P. Nivea Aureo-Intertexta.—A variety the leaves of which are variegated with golden colored interlacings.

P. Candicans or Balsamifera (Ontario Poplar).—A handsome, erect growing species with large leaves, the glutinous buds of which give out a strong balsamic odor in spring.

P. Candicans Elongata.—An interesting variety of the preceding species, or, according to Professor Dippel, the offspring of a cross with P. laurifolia.

P. Trichocarpa.—A new kind from N. America, with still broader leaves than those of P. candicans.

P. Tristis.—Another variety of P. candicans with small leaves, dwarf habit of growth, rugose bark, and foliage of a very dark tint from its first appearance.

P. Angulata or Macrophylla.—Bark thick and angularly ridged. The leaves of this species are larger than those of any other known Poplar.

P. Suaveolens.—A sub-variety of P. candicans with shorter branches and stouter buds, giving out a still more powerful odor than its parent does.

P. Nigra Betulæfolia.—Resembles the Italian Poplar, but has smaller leaves like those of the birch tree.

P. Fastigiata (the Lombardy Poplar).—Well known as the most pyramidal in growth of all the Poplars.

P. Fastigiata Robusta.—A new and improved variety of the preceding species, which it excels in vigor of growth. It is anticipated that it has before it a future of note.

P. Plantieriensis Mascula and P. P. Fœmina.—Forms of the Lombardy Poplar, of which the sex has been fixed by arboriculturists.

In addition to the foregoing we may mention P. Cordata and P. Rotundifolia, varieties whose specific names sufficiently indicate the peculiarities of their foliage, and concluding with the famous P. Ouphratica, we think we shall have enumerated all the kinds of Poplars which are now known. This last named species was sent to us from the country of Salix Babylonica a few years ago, and is as yet hardly known to

European planters. It appears to be an exceedingly singular kind of tree, as when it is fully grown its foliage undergoes an extraordinary transformation, and travelers inform us that the same tree will exhibit on its lower branches leaves as round as those of the Judas tree (Cercis Siliquastrum), while the leaves on the upper branches have all the appearance of willow leaves.—Letellier et Fils, Caen (Calvados), France; The Garden.

THE EIGHTIETH BIRTHDAY OF PRINCE BISMARCK.

ON April 1 Prince Bismarck completed the eightieth year of his eventful life. The world joins with the German empire in congratulating her "Grand Old Man." The emperor began to commemorate the anniversary by honoring the veteran statesman with a personal visit. Four hundred members of the upper and lower houses of the Prussian Diet and of the Reichstag went to Friedrichsruh on March 25 to pay their tribute of affection and esteem. The prince delivered a brief patriotic speech in reply to their congratulations. "If I were in robust health," concluded Prince Bismarck, "I could say much more to you, but I am a feeble old man. I deplore that I am no longer able to work with you, but I am not strong enough to face the multifarious trials of an existence in Berlin. I am old and indolent, and I wish to end my days in the house which I now inhabit. But my thoughts are with you, perhaps to a greater extent than is fitting for a man of my age. But I cannot suddenly abandon my former ideas, because I am old and ill. They never leave me. I cannot give better expression to the sentiments which fill my heart than by requesting you to cling fast to the imperial idea, even in the Prussian Diet, not to forget that you are citizens of an empire, and to think of him who is your king and emperor, and who has duties toward the empire and his confederates. I beg you not to pursue a Brandenburg or a royal Prussian policy, but an imperial German policy." Prince Bismarck then called for cheers for the emperor, which were enthusiastically given. A varied programme, sufficient to tax the strength of a much younger man, has been arranged for the next few days. Prince Bismarck, as will be seen by his latest portrait, has visibly aged.—Illustrated London News.

PRINCE BISMARCK ON HIS EIGHTIETH BIRTHDAY.

[THE GARDENERS' MAGAZINE.]

CHARLES LINNÆUS.

CHARLES LINNÆUS, the eminent botanist, who has been most justly designated the Prince of Naturalists, was born on May 24, 1707, at Rashult, in Sweden. He was the child of poor but respectable parents, who professed the Protestant religion. His early youth, like that of so many who have subsequently achieved fame and renown, was passed in a constant struggle with poverty and misery, those frequent attendants at the cradle of genius. Destined by his parents for an ecclesiastical life, Linnæus early left home to enter college, which, in the land of his birth, is alike open to the poor and the rich. Here, however, he evinced but little inclination for those studies necessary to be pursued by one destined for the church, his love for botany having at that early period of his life already become the all-absorbing passion of his mind. Being after a time stigmatized by his master as a dunce, he shortly found himself compelled to seek a livelihood in the service of a charcoal burner. However, at length a friendly doctor of his native town persuaded the elder Linnæus that his son was endowed with much greater talents than he was generally credited with, and as the result of this expression of opinion young Linnæus again returned to the college. After a few years had elapsed he was sent to the University of Lund, and subsequently to the Swedish students' goal, Upsala. At this period of his life, to which he often afterward looked back with pleasure, he found himself compelled to mend his fellow students' shoes as a means of increasing his scanty funds of subsistence. This state of life, akin to destitution, proved, happily, but of short duration, for one Olav Celsius, a man well known for his great erudition, formed his acquaintance at this time, and very soon associated him with himself in his labors. He gave him a lodging, a place at his table, and procured him access to a valuable library. The Upsala Academy of Science shortly after sent him into Lapland at the expense of the state to study the natural history of that country. Linnæus at this time was only in his twenty-fifth year, but he gave proofs in this expedition of the most wonderful diligence and perseverance. In six months' time he traversed on foot an extent covering two hundred and fifty leagues of country, not including those deviations from the beaten track which must necessarily be made when natural history is the object of investigation. The adventurous traveler suffered many privations in this wild country, where he was oppressed by heat during the brief summer and benumbed by cold during the long succeeding winter. The young naturalist climbed mountains, crossed streams and rivers and penetrated the darkest caverns, encountering great difficulties on his way. The fruits of this journey were a splendid collection of plants, insects and minerals, which became the property of the University of Upsala, where it still remains and is much prized. He also wrote a valuable work on the natural riches of Lapland. After a short interval of rest, Linnæus went to visit the Swedish mines, and applied himself with so much ardor to the study of mineralogy that on his return to Upsala he was fully qualified to lecture on the subject. He made such rapid progress that he excited the jealousy of Prof. Rosen, a well known savant of the day, and the result was that his course of lectures was suspended by order of the authorities. Justly irritated by this proceeding, Linnæus went himself to Rosen and provoked an altercation, but, happily, his good friend Celsius interposed his mediation, with the result that a reconciliation was effected between Linnæus and the professor.

However, shortly after this event he came to the conclusion that it would be best for him to quit Upsala, and accordingly he departed to practice medicine in other Swedish towns, among others Telgum, where he fell in love with a young lady, the daughter of a Dr. More, to whom he was soon betrothed. He then went to Denmark, traveled over part of Germany, and finally passed over into Holland, at that time famed for its vegetable products, with the intention of taking up his residence in that country for a time. It was during his visit to Hamburg that he exposed an imposture that had caused a great sensation in that city. This was the seven-headed hydra. Linnæus attentively examining the monster discovered that it was nothing else than seven hares' heads skillfully put together and covered with the skin of a serpent. Among the Dutch gardens of that period the one richest in exotics was situated at Harlecamp, belonging to a renowned amateur cultivator of the name of Clifford. Linnæus, who notwithstanding his growing celebrity still felt himself in a precarious state as regarded his circumstances, offered his services to the gentleman in the capacity of gardener, in order to provide for his now pressing necessities. His offer was accepted, and he worked there for a time without his identity being discovered. One day, however, he was recognized by a gentleman who had seen him at Upsala, and thus his incognito was speedily put an end to, and he would most probably have forthwith quitted the place had not Mr. Clifford anxiously sought to retain him by the offer of a situation of director of his magnificent gardens. He gladly took the place, and it was here that, at his employer's expense, he published the well-known work in which he gave to the world the new system of classifying plants to which his name has been given. This generous patron insisted on Linnæus keeping the proceeds of the sale of his work, and, moreover, furnished him with the means to travel in England.

Linnæus made numerous disciples in this country, and such was the enthusiasm with which his discoveries were received, that he was for some time doubtful whether he should make this country his home. But he finally determined to return to Sweden, visiting France on his way, and at length landed once more on the shores of his native country, whither he may be said to have been called by the unanimous voice of his countrymen. This was in the year 1738, and from that time forward he enjoyed a life of uninterrupted outward happiness, and of brilliant success. United to the daughter of Dr. More, to whom as before stated he had long been betrothed, he was soon chosen as botanist to the king, president of the Academy of Stockholm, professor of anatomy in the University of Upsala, and, moreover, professor of botany and director of the botanical gardens. In fact, he attained the highest position to which a man of science could attain in Sweden, inasmuch as the government of that country interdicted to scientific men all situations which could in any way turn them from their pursuits. Satisfied with this private life at home, Linnæus declined several lucrative appointments that were offered to him by foreign sovereigns. Here he passed the latter half of his life, until at length, toward the close of 1775, he was, on the occasion of his delivering a lecture on the different botanical systems, seized with an apoplectic fit. This attack was followed two years later by another, which deprived him of the proper use of his faculties, and soon afterward brought him to the grave, on January 10, 1778, in the seventy-first year of his age.

All the inhabitants of Upsala displayed mourning on the day of the obsequies of this great botanist, whose biography has been here briefly narrated. The king of Sweden caused a medal to be struck in his honor, raised a monument to his memory in the Cathedral of Upsala, and delivered a discourse in eulogy of him before the States of Sweden.

In stature Linnæus was above the middle height, slight, but well made; his head large, his countenance frank and open, and his quick, clear eye betokened an intellect of uncommon acuteness. His constitution was robust, and he withdrew from his occupations only when he felt his mind no longer capable of pursuing a continuous train of thought. Possessing a spirit of no ordinary depth and superiority, Linnæus ever united the profoundest study of nature with the proper respect due to religion. Over the door of his study was inscribed these words, "Live innocently; God is present." The first lines dictated by this great man for the opening of his work, entitled "Systema Naturæ," contain an admirable profession of faith. The influence he exercised over the age in which he lived was prodigious. He not only submitted to certain rules the study of the natural sciences, but also impressed a new character on the physical sciences in general, and gave the public mind an impulse toward order and method. It may be added that through his lucid system of classification he greatly abridged the labors of his successors, and thus conduced materially to the advancement of science, as well as to the progress of the human mind. W. NORMAN BROWN.

DOES A NUCLEUS EXIST IN THE RED CORPUSCLES OF MAMMALIAN BLOOD?

By Professor JOHN MICHELS, late Chief Microscopist, Bureau of Animal Industry, U. S. Department of Agriculture.

THE importance of the blood as the vital principle of the human body is, of course, a recognized fact, known to everybody, and the recent discovery of the use of antitoxine has made it evident that the condition of the blood can protect us from the most deadly diseases and, on the other hand, blood containing poisonous elements will cause in some cases almost instant death, or after a short interval, according to the nature of the poison.

It is a remarkable fact that although a knowledge of blood is of such importance, and probably the key to a perfect knowledge of the treatment of disease, little or next to nothing is known relating to its physical properties, its constituents, or its effects on the human economy, in health or disease. No physician ever makes a microscopical examination of blood in making his diagnosis, and if he did, he would be unable to interpret the appearances he would notice, for there is no guide to the subject, the medical profession remaining under a cloud of ignorance in regard to this matter, and they appear to be content to wait and have this knowledge forced upon them by chemists and biologists rather than make any effort on their own part to relieve their condition of disgraceful ignorance.

In man blood consists of a clear fluid, the liquor sanguinis or plasm, in which a large number of corpuscles are distributed. Of these there are two prominent varieties, differing much in character, the red and the colorless or white. The former are greatly in excess, and give to the fluid its characteristic red appearance. In one hundred volumes of blood there are said to be thirty-six volumes of corpuscles and sixty-

four of plasma. This ratio is, however, subject to frequent changes.

The red corpuscles in man and most mammals are bi-concave bodies, circular in outline, but in birds, amphibia and most fishes, they are also bi-concave, or hollowed out in the center, but have an elliptical contour. There is a remarkable exception in the contour of the red corpuscles of the camel and animals of the camel tribe, as they have them elliptical, like the blood of fish, birds and reptiles, which is an extraordinary fact, which science has not been able to explain. I have myself examined camel's blood and found it as above stated.

Under the microscope a nucleus is always found in the blood of birds, fish and reptiles, when the red corpuscles are examined, but all text books claim that no nucleus exists in the red corpuscles of man and the mammals, although they are found in the fetal stage.

Knowing that the nucleus is the vital and most important part of all cells, and that the nucleus was mammalian red blood corpuscles has been opposed by several biologists, a member of the Johns Hopkins University faculty stating that there was no resisting the fact that I have seen and photographed something that has the optical appearance of a nucleus, still as they could not show it themselves by their methods, it could not be a nucleus, but something else, what else they could not say. I have, however, submitted my work to every possible test, and while perfectly aware of all the errors of misinterpretation which are possible (see my own article in the Popular Science Monthly, on the misinterpretations of the microscope), I still consider my position to be correct.

I will now explain my methods to enable any microscopist to test my work for his own satisfaction.

Draw blood from the finger. I find the best method is to cut the skin with a knife on the upper part of the nail, when the blood will flow freely, pricking the finger being painful. Place a drop of the blood on the ordinary 3 by 1 glass slide, and taking another slide, place the end in the blood and draw it rapidly across puscle, the only one present. Fig. 2 shows what the Germans call a homogeneous corpuscle. Fig. 3 a red corpuscle showing nucleus and nucleolus. Fig. 4, red corpuscle well in focus showing nucleus. Fig. 5, granular red corpuscle.

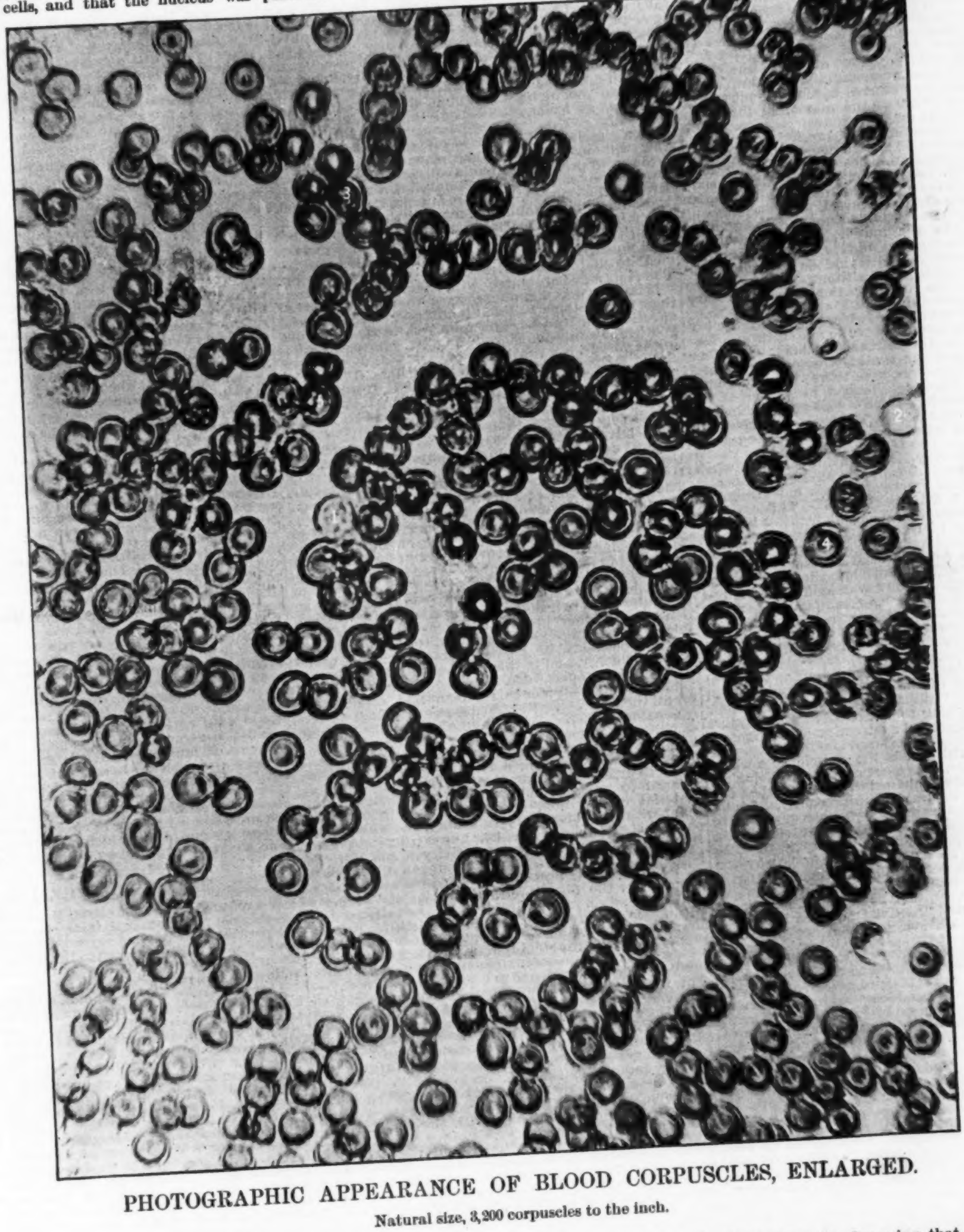
The specimen of blood not having been pressed under glass cover, the corpuscles are not on one plane. This accounts for many being out of focus. The photograph was taken with a dry one-eighth by Powell & Lealand.

[Continued from Supplement, No. 1008, p. 16118.]

ON THE NATURE OF MUSCULAR CONTRACTION.*

The physiologist may deem his purpose attained when he succeeds in tracing a certain vital phenomenon back to processes which may also be observed in lifeless bodies.

However, though we should, perhaps, be inclined to



PHOTOGRAPHIC APPEARANCE OF BLOOD CORPUSCLES, ENLARGED.

Natural size, 3,200 corpuscles to the inch.

present in the red corpuscles of fishes, birds and reptiles, I have reasoned by analogy and come to the conclusion that the nucleus must be present in the blood corpuscles of man and all mammals. To prove this I have for many years carried on a series of microscopical experiments to demonstrate the fact.

By adopting new methods in staining and preparing blood, I found that I could show them under suitable powers in the microscope, both a nucleus and a nucleolus in mammalian red blood corpuscles, and have succeeded in demonstrating the fact by photography, and believe this is the first time it has been accomplished and published.

All new discoveries in science meet with opposition when they are contrary to the recognized dictum of authorities on the subject, especially when the new discovery is in opposition to the text books, which are held sacred in the eyes of the average academic professor. Thus my demonstration of a nucleus in the the glass, by which means a single layer of corpuscles will be obtained. Allow this to dry, and then pour on some iodine which has been diluted with water. Pour off and allow to dry. Examine with a dry ⅛ or $\frac{1}{16}$ inch objective. If you have no lens which cannot be corrected for objects viewed without a cover, you can place the blood on the under side of the glass cover, and attach same to glass slide, not using Canada balsam or any other medium.

It is really a most important matter to decide if the nucleus does exist in the red corpuscles of man and other mammals, and I will be glad to have my work confirmed, or explained, so that the question can be settled one way or the other.

Description of Photograph.—This photograph represents human blood, the average size of the red corpuscles being $\frac{1}{3200}$ of an inch. The original photograph measures 2¾ by 2 inches, the enlargement here shown is 9⅛ by 7⅛. Fig. 1 represents a white cor-

infer from the foregoing that we have successfully acquitted ourselves of this task with regard to muscular contraction, we will be careful not to overlook the numerous important respects in which a muscle as a living body, that is one subjected to constant chemical transformation, differs from our lifeless strings. The study of these differences is most instructive, since it throws a new light on a series of processes nearly allied to contraction, especially on the phenomena of rigor mortis and tonus of muscle.

But before entering into this we shall first have to meet another important objection to our views. It is based upon the absolute amount of muscular force. This amount may, as you know, be very high. Human muscles at the strongest tetanic contraction can shorten with a force of about 10 kilogrammes to 1 sq.

* The Croonian Lecture, delivered by Prof. Th. W. Engelmann, at the Royal Society, on March 14.—Nature.

cm. transverse section. Now such a force must, according to our view, be produced by a small part only of the transverse section of the muscle.

With a maximal tetanus, it is true, the temperature of the whole muscle does rise 1° C. or more. Hence there are, perhaps, 1,000 times more particles chemically active than with a moderate simple contraction, where the temperature rises 0·001° C. only. Consequently, during such a tetanus, a much greater part of the muscular substance—perhaps 1,000 times as much—will be heated to such a degree as is required for an obvious contraction of the inotagmata. But even in this case the greater part of the whole substance will be only moved passively.

Can such very important mechanical powers as we are obliged to assume in the inotagmata be evolved through the thermical contraction of doubly-refractive bodies? Do we not, as Fick says, in making such a supposition, go too far beyond the bounds of legitimate analogy?

Of course nothing but the measurement of the forces developed by lifeless doubly-refractive bodies under thermal contraction will decide this question. I have made many of these measurements on various objects, and I think the results afford us a refutation of the objection. Strings, moist but not yet contracted through lying in water, with a diameter of 0·7 mm., and loaded with 1 kilogramme, lifted up the weight in a perceptible degree when rapidly heated up to 130° C.; that is to say, they exerted a force about twenty times at least as great as the maximum force of a human muscle of the same thickness.

Still greater forces may be exerted by strips of caoutchouc rendered in a high degree doubly refractive by strong extension. Even by merely heating from 20° to 40° C. powers could be produced sixty times as great as the maximum afforded by human muscles of the same transverse section.

Hence we may sufficiently account for the greatest display of force in the muscle, without having to attribute to the inotagmata higher elastic forces than we observe in highly extended threads of caoutchouc of the same thickness, nay, without even having to assume temperatures reaching the degree necessary for the coagulation of albumen.

It is a pity that we are not able to subject the isolated doubly-refractive parts of the muscle in an unimpaired condition to the influence of heat. Together with the elevation of temperature there occur changes in the chemical processes, and therewith in the material composition and mechanical properties, of the whole muscle substance, which complicate the changes dependent only on the heating of the doubly-refractive particles, or even prevent our clearly recognizing them.

Tetanus and Rigor by Heat.—Living muscles, when being gradually heated, will, as you know, contract tetanically so soon as the temperature has attained a height which is but little below 50° C. This so-called tetanus of heat passes by prolonged heating into the lasting contraction of rigor, in this case combined with definitive loss of irritability.

This contraction through heat agrees at so many points with physiological contraction, especially with physiological tetanus, that it was held to be a last manifestation of muscular life. Such points of resemblance are, e. g., the amount and the force of shortening, which in both cases are at least of the same order, and the increased production of heat, carbonic acid and a fixed acid.

No doubt in this case a very important and general rise of temperature of the contractile particles will take place so soon as rigidity begins to announce itself. Consequently, according to our hypothesis, we must expect a strong and general contraction of the inotagmata.

That the force, with which the muscle as a whole will shorten, is not quite so great as with physiological tetanus, is sufficiently explained by the fact that the inotagmata do not contract simultaneously, and by the increase of internal resistance which occurs, due to coagulation and precipitation in the muscle plasma during the development of rigidity by heat. The latter circumstance seems to explain, too, why the rigid muscle does not perceptibly lengthen, or lengthens very little, upon cooling.

Turgescence by Absorption as a General Cause of Contraction of Doubly-refractive Organized Elements.—On a closer examination, however, we find that matters are still more complicated, and likewise that there is still an important circumstance which, besides the rise of temperature of inotagmata, may act as a cause of contraction, even of permanent contraction. This circumstance, the fundamental importance of which to muscular contraction was disclosed a score of years ago by a rigorous microscopical examination of the processes taking place in the muscle fibers during contraction, is the turgescence of the doubly-refractive elements by the absorption of watery liquids.

All histological elements possessing doubly-refractive power tend, even at an ordinary low temperature, to shorten in the direction of the optical axis when their volume is enlarged by the absorption of a watery fluid, and to lengthen when their volume diminishes by loss of liquid. The extent, power and rapidity of the changes of form depend on the nature and on the dimensions of the turgescent object, and on the nature and quantity of the absorbed liquid.

For the examination of these relations our violin strings again yield fit material. A long series of measurements has now shown that there is a very far-reaching resemblance between contraction by turgescence and thermal and physiological contraction. I may mention the marked extent of the shortening, the high value of the force of contraction, its increase with the initial tension and its decrease with increasing shortening, the increase of extensibility, the decline of refractive power and of doubly-refractive property. The resemblance is by no means exclusively of a qualitative, but also of a quantitative kind.

A change of form generally takes place when the composition of the absorbed liquid changes, and it is of great importance to our question that even the slightest changes of composition can cause marked contractions and great mechanical effects.

Unloaded E strings, e. g., contract in pure water to nine-tenths, and in water which contains 0·25 per cent. only of lactic acid to three-fifths of the initial length. At 15° C. they exert, in the first case, forces of about 80 g., in the second of about 110 g. By absorbing a 0·25 per cent. solution of lactic acid at initial tensions of 5, 215 and 425 g. there were exerted powers of 115, 350 and 490 g. respectively, i. e., forces very much higher than a muscle of the same thickness can produce during tetanus.

Upon neutralization or dilution the old length and volume return. The doubly-refractive fibrils, or the sarcous elements of muscles, contract considerably also under the same conditions, swelling at the same time; this is the case even with muscles which have been killed in alcohol. In such instances I measured in the striated fibers of insects shortenings to 50 per cent. and more.

Since, according to many inquirers, lactic acid is formed during the rigor of striated muscles, and, at all events, the reaction of the muscular plasma becomes acid, the doubly-refractive elements must necessarily swell more and tend to shorten, and this contraction will remain until the acid has been neutralized or removed by diffusion.

Similar results will follow in other cases of rigor characterized by shortening and by the production of much acid. Nay, in the bloodless muscle even a physiological stimulation, when sufficiently strong and long, may be expected to produce a lasting shortening, on account of the gradual increasing acidity. Indeed, the well-known incomplete relaxation of such muscles seems to me to be a symptom of this chemical contraction, as it may be called, in contrast with the thermal.

In a muscle in which the blood stream is maintained this will not so easily take place, not even under a strong and prolonged stimulation, because the acid is immediately neutralized or removed through diffusion. Even in the isolated, bloodless muscle, the acid, which is produced by stimulation, may, in the beginning at least, be rendered harmless through the very large quantity of non-acid fluid absorbed by the muscle. Consequently we must expect in these cases an immediate and complete relaxation after contraction. The facts agree absolutely with these suppositions.

It is, perhaps, not unnecessary to remark that all these observations would also hold good if the material affecting the turgescence were not lactic acid, but another substance arising during the chemical action in the muscle, e. g., water.

The Different Parts Played by "Thermal" and by "Chemical" Contraction in the Different Kinds of Muscular Contraction.—But now the question may be raised, Is not physiological contraction due to turgescence solely?

We have all the more reason to put this question, since we can prove that in the physiological contraction of striated muscle fibers the doubly-refractive layers swell at the cost of the watery isotropic layers. The microscopical examination of active living muscles and of fixed waves of contraction has proved this fact beyond all question, however much the opinions of different observers may diverge on other points. The swelling would, moreover, account for the slight decrease of muscular volume observed in strong tetanic contraction. For, according to the experiments of Quincke, the absorption of water by organized bodies generally leads to a slight condensation.* By this condensation further heat is developed, and this heat might, by raising the temperature of the doubly-refractive elements, be partially transformed into mechanical energy, and in this way contribute to the production of muscular force.

Yet I cannot consider this explanation as sufficient for all the facts. The same argument which in our eyes seems to dispose of the hypothesis of the identity of chemical attraction and muscular force, viz., the infinitesimally small quantity of substance which is chemically active during a simple contraction, seems to me to present a fundamental difficulty here also. It is hard to understand how, through a change in the material composition, effected at one infinitesimal point within a soft watery substance, the whole mass should shorten and thicken, unless there proceeds from the center of chemical activity a considerable amount of kinetic energy throughout the substance.

The microscopic appearances which prove the turgescence of the doubly-refractive elements during a contraction do not exclude a direct thermo-dynamical effect. For the almost complete identity in the changes of form, and of the optical and mechanical properties which the doubly-refractive constituents of all histological elements undergo during chemical and thermal contraction, seems to bear out the hypothesis that, in the thermal shortening of doubly-refractive elements, through the absorption of watery fluid, we get a shifting of solid and liquid substances analogous to that of turgescence. With most of the microscopical appearances, especially the so-called fixed contraction waves, we have, moreover, to do with a high degree of tetanic contraction, or even with rigor, in which, on account of the greatly increased chemical action, a chemically-caused turgescence may have combined in a considerable degree with the thermal contraction.

Hence, we may conclude that chemical contraction by turgescence of the inotagmata is most likely a constant concomitant of the thermal contraction of living muscle, but that compared with the latter, in a single contraction at least of striated fibers, the former is of little or no consequence as regards the shortening effect.

Chemiotonus and Thermotonus.—Both processes will probably also take part in varying proportion in the tonus of muscle, which in some cases will approach more to pure chemiotonus, in others more to pure thermotonus.

Causes of the Relaxation of Muscle—Theoretical Considerations—Conclusion.—With regard to the relaxation of muscle, according to our theory, this must be caused either by cooling or by the withdrawal of water from the doubly-refractive particles. Indeed, we have found that generally doubly-refractive histological elements, even if they be lifeless like our violin strings, lengthen again upon cooling after they have been contracted by heat, and that they lengthen upon neutralization or diffusion, after they have been contracted by absorption at an ordinary temperature.

In a normal relaxation the muscle seems to return completely to its initial state. Of course its store of energy has diminished in proportion to the quantity of mechanical work and heat which have proceeded from it, but, on account of the relatively infinitesimal quantity of substance which is thereby consumed, this return will necessarily seem to be complete even in the case of the isolated muscle.

When analyzing the phenomena of relaxation more exactly, we shall light on several possibilities, the discussion of which would be very interesting with regard to the theory of muscle life. I shall restrict myself to the phenomena of the relaxation following on thermal contraction.

Here, in the first place, we might conceive that the doubly-refractive inotagmata are destroyed in the thermal shortening, so that each of them performs its function once only. The lengthening of the muscular fibrils would then probably be caused solely by the elastic powers of the parts passively extended or compressed by the shortening of the inotagmata. Upon a fresh stimulation other inotagmata would, in consequence of the combustion of other thermogenic molecules, be active, perish, etc. Through the activity of the formative matter of the living muscle fiber, the place of the lost inotagmata would be continually or periodically filled by others, probably through the same process of organic crystallization by which during ontogenesis the doubly-refracting particles in the muscle are produced and disposed.

Against this hypothesis, however, or at least against its general validity, various objections may be put forward. I will mention two only of the most important of them.

There seems to be no doubt but that the doubly-refractive particles of the muscle consist of an albuminous substance, and that they together make up a sensible part of the whole albumen of the muscle fibrils. In that case it would be most improbable that a great increase of muscular work should not at all, or very slightly only, increase the elimination of nitrogen. To account for this, we should have to recur to an auxiliary hypothesis, and assume either that the nitrogenous remainder of the destroyed inotagmata is retained within the body—perhaps in the muscle—for purposes of anabolism, or, which is most improbable indeed, that other organs saved just as much albumen as was decomposed above the normal quantity during the contraction of the muscles.

A second objection consists in the fact that after heating tetanizing muscles until they are rigid, the doubly-refractive power of the sarcous elements will be found still very great.

The other possibility is that the inotagmata may be preserved, and consequently on cooling may return to their former state, and therefore will do work by shortening as often as we choose. In this case muscle would not only seem to offer, but would offer in fact, a most striking resemblance to a thermodynamic machine, the solid particles of the framework of which are not destroyed through the chemical process producing the actual energy. No more than such a machine would the muscle require a perpetual renewal of the framework for the continuation of its activity; it would only want a periodic supply of fresh heating material.

This representation, as you see, will sufficiently account for the fact, which would otherwise remain surprising, that muscular work has such a small influence on the elimination of nitrogen. The facts of microscopic observation also agree with it.

But a further discussion of the two possibilities would lead us too far. The purpose of this lecture was not to record a complete inquiry into all the phenomena of muscular activity. I have wished chiefly to draw attention to a series of facts which I hold to be of great importance for a deeper insight into the essence of muscular contractility, in so far as they prove the existence of certain material dispositions and processes (admitting of closer experimental examination), by means of which mechanical work may be generated in the muscle by chemical energy.

TERRESTRIAL HELIUM (?)

WE referred recently to Prof. Ramsay's discovery of another new gas obtained from cleveite. The following papers, by Prof. Ramsay and Mr. Crookes, on this subject were communicated to the Chemical Society at its anniversary meeting.

Prof. Ramsay's paper was as follows:

In seeking a clew to compounds of argon, I was led to repeat experiments of Hillebrand on cleveite, which, as is known, when boiled with weak sulphuric acid, gives off a gas hitherto supposed to be nitrogen. This gas proved to be almost free from nitrogen; its spectrum in a Pflucker's tube showed all the prominent argon lines, and, in addition, a brilliant line close to, but not coinciding with, the D lines of sodium. There are, moreover, a number of other lines, of which one in the green blue is especially prominent. Atmospheric argon shows, besides, three lines in the violet which are not to be seen, or, if present, are excessively feeble, in the spectrum of the gas from cleveite. This suggests that atmospheric argon contains, besides argon, some other gas which has as yet not been separated, and which may possibly account for the anomalous position of argon in its numerical relations with other elements.

Not having a spectroscope with which accurate measurements can be made, I sent a tube of the gas to Mr. Crookes, who has identified the yellow line with that of the solar element to which the name "helium" has been given. He has kindly undertaken to make an exhaustive study of its spectrum.

I have obtained a considerable quantity of this mixture, and hope soon to be able to report concerning its properties. A determination of its density promises to be of great interest.

The spectrum of the gas was next discussed by Mr. Crookes, who said:

By the kindness of Prof. Ramsay I have been enabled to examine spectroscopically two Pflucker tubes filled with some of the gas obtained from the rare mineral cleveite.* The nitrogen had been removed by "sparking." On looking at the spectrum, by far the most prominent line was seen to be a brilliant

* In the thermal contraction of tendons and strings I have not yet been able to convince myself of a decrease in volume.

* Cleveite is a variety of uraninite, chiefly a uranate of uranyle, lead, and the rare earths. It contains about 13 per cent. of the rare earths and about 2·5 per cent. of a gas said to be nitrogen.

yellow, one apparently occupying the position of the sodium lines. Examination with high powers showed, however, that the line remained rigorously single when the sodium lines would be widely separated. On throwing sodium light into the spectroscope simultaneously with that from the new gas, the spectrum of the latter was seen to consist almost entirely of a bright yellow line, a little to the more refrangible side of the sodium lines, and separated from them by a space a little wider than twice that separating the two sodium components from one another. It appeared as bright and as sharp as D_1 and D_2. Careful measurements gave its wave length 587·45; the wave lengths of the sodium lines being D_1 589·51 and D_2 588·91. The differences are, therefore:

	Wave Lengths.	Differences.
D_1	589·51	
		0·60
D_2	588·91	
		1·46
New line	587·45	

The spectrum of the gas is, therefore, that of the hypothetical element helium, or D_3, the wave length of which is given by Angstrom as 587·49, and by Cornu as 587·46.

Besides the helium line, traces of the more prominent lines of argon were seen.

Comparing the visible spectrum of the new gas with the band and line spectrum of nitrogen, they are almost identical at the red and blue end, but there is a broad space in the green where they differ entirely. The helium tube shows lines in the following positions:

	Wave Length.	
(a) D_3, yellow	587·45	Very strong. Sharp.
(b) Yellowish green	568·05	Faint. Sharp.
(c) Yellowish green	566·41	Very faint. Sharp.
(d) Green	516·12	Faint. Sharp.
(e) Greenish blue	500·81	Faint. Sharp.
(f) Blue	480·63	Faint. Sharp.

I have taken photographs of the spectrum given by the helium tube. At first glance the ultra-violet part of the spectrum looks like the band spectrum of nitrogen, but closer examination shows considerable differences. Some of the lines and bands in the nitrogen spectrum are absent in that from the helium tube, while there are many fine lines in the latter which are absent in nitrogen. Accurate measurements of these lines are being taken.—Nature.

WAVES AND VIBRATIONS.

AT the Royal Institution Lord Rayleigh, F.R.S., recently delivered a course of six lectures on "Waves and Vibrations." In his first lecture, after giving a brief account of the nature of wave forms, he said that he proposed that day to deal more especially with waves of water. In such waves the velocity was not independent of the wave length (or distance between crest and crest), as it was in the case of sound waves, which in air moved with the same speed whether they were long or short. With waves of water the long ones traveled more quickly than the short. Waves at sea were mostly generated by wind, though other causes, such as earthquakes, occasionally operated. By blowing the surface of a long trough of water with a powerful fan, the lecturer showed that the waves produced close to the source of the wind were shorter than those set up further away. The effect of oil upon waves was also illustrated and explained. Oil had no effect upon big rollers, but the broken water upon which it acted was just what was dangerous to boats in a tempest. A storm in midocean generated waves of all lengths, but at a distance a kind of regularity was found, since the long waves arrived first, the shorter ones following afterward. In the island of Madeira, the lecturer said, he had observed waves with the long periodic time of ten seconds. The height of waves in the sea had often been exaggerated, owing to the difficulty of measuring them, but the highest authentic observation was about forty feet. The lecturer next discussed stationary waves as opposed to the progressive waves of which he had been speaking. They were described as the result of the meeting of two perfectly equal sets of progressive waves, and the production of two systems of them was shown in a round tank. Lord Rayleigh then spoke of the effects of waves on ships. He showed a small model boat so weighted as to have the same rolling period as the waves in the tank in which it floated. The result was that its rolling was exceedingly violent, but became comparatively slight when the weights were altered so as to change the rolling period. Warships, in which stability was very essential, were designed to have a longer period of roll than any waves they were likely to encounter. The lecture was concluded with some remarks on standing waves, which, it was explained, would be formed in a river flowing four miles an hour by a wave traveling up it at the same speed. The waves produced would be standing as regards an observer on the bank, but progressing as regarded the water.

In his second lecture, Lord Rayleigh, after showing a form of wave which he had been unable to produce satisfactorily at the preceding lecture pointed out that if a body was capable of vibrating in several different ways the various vibrations might, within certain limits, go on together. On this fact, he remarked, depended the possibility of music. He next raised the question, What was the motion of the particles of water in a progressive wave at sea? and answered that it was both vertical and horizontal. In deep-water waves it was circular, and greatest at the circumference. The depth to which it penetrated depended on the wave lengths, but was probably greater than was sometimes supposed. Geologists, he thought, had not adequately noticed the movements which waves caused on bodies at the bottom of the sea. After waves at sea had once been formed, it was easy to understand, he remarked, how the wind following the waves increased their height, and, vice versa, "knocked the sea down" in nautical phrase, when it changed and blew in a direction opposed to their motion. He next considered very small water waves. These might be obtained with a periodic time of 1-1,000 of a second. Their formation was governed not so much by gravity as by capillary force, and there was a certain size of wave which, owing to the joint action of those two factors, had a smaller velocity of propagation than any other size—greater or less. To make these small waves Lord Rayleigh employed two tuning forks of the same pitch, to whose prongs were attached corks which dipped in a vessel of water. So long as the vibrations of the forks were equal in number, the system of waves set up was stationary. When, however, one fork was made to vibrate more slowly than the other, the waves traveled in the direction of the former. Another way, devised by Faraday, of obtaining these small waves was also shown. The lecture concluded by explaining some methods of observing phenomena which were so rapid as to elude the eye. The most obvious device was to employ instantaneous photography. The magnesium flashlight lasted only one-tenth of a second, but was much too long for some purposes. But the electric spark was a resource that never failed; it could be made to last only a millionth of a second, and that was instantaneous enough for anything that ever happened. To illustrate its use some photographs of the bursting of a soap film, which took place in 1-200 to 1-300 of a second, were thrown on the screen.

In his third lecture, Lord Rayleigh passed to the discussion of waves which were long in comparison with the depth of water. In that case, he said, there was a different state of things, the velocity of propagation being constant and independent of the wave lengths. The theory of such waves was therefore analogous to that of sound waves. Scott Russell distinguished them into positive and negative, or humps and depressions in the general surface. He made observations on the towing of boats along canals, and noticed that, when a boat was stopped, the wave which accompanied it went on and was sometimes traceable for miles. This wave, of course, traveled at a constant speed, and a boat going faster than that speed met with less resistance from the water than it did when going more slowly, since it outstripped the accompanying wave which caused considerable waste of power. On this fact, which became known by the accident of the horse attached to a boat on a canal taking fright and running away, depended the running of the fly boats formerly employed on some Scotch canals. The tides were the most important long waves of all, and as was well known, were caused by the attraction of the moon and sun. The theory of them was very complicated, among the difficulties being the varying depths of the sea and the irregular configuration of the land. Lord Rayleigh then proceeded to discuss aerial waves. Waves of sound, he said, usually originated in vibrating bodies, such as tuning forks. The latter were convenient as standards of pitch, and if once adjusted, might be treated as such, only slight corrections being required for variations in temperature. The phenomenon of beats was next explained. If two forks were vibrating, at a certain moment their effects co-operated in the ear. If they were of the same pitch, the co-operation continued; if not, it could not last, no sound being heard by the ear when the condensation and rarefaction produced by the forks in the air were equal. The beats were the alternations of co-operation and antagonism. If the pitch of one fork was known, it was possible to find that of the other by counting the beat. Thus, if there was one beat a second, it followed that one fork made one vibration more or less than the other in that time. If the known fork vibrated, say, 256 times a second, the other would vibrate either 255 or 257 times, and whether it was sharper or flatter could be experimentally discovered by making a slight change in the weights on its prongs. Sound traveled in air at the constant rate of about 1,100 feet a second, unless it was excessively violent. Its velocity was first calculated by Newton, but his result was too low; Laplace first accounted for the error. Lord Rayleigh then showed how the velocity might be indirectly obtained by the use of resonators. The invisibility of air was a difficulty in the investigation of sound, but still some effects could be made apparent to the eye. If a piece of paper was hung in the mouth of a resonator by a silk fiber, it would stay in any position indifferently. But if a tuning fork of about the same pitch as the resonator were excited in the neighborhood, the piece of paper would place itself in the position of maximum obstruction across the alternating current of air flowing in the mouth of the resonator. In conclusion, Kundt's phenomenon was shown. Longitudinal vibrations were set up in a long tube containing some cork dust, and the distribution of the latter caused by them showed the location of the nodes and loops. The velocity of sound in the particular gas with which the tube was filled could be calculated from the distances separating the nodes, where the dust appeared as striations across the diameter of the tube. Lord Rayleigh mentioned that he had used this method in his researches on argon.

In his fourth lecture Lord Rayleigh began with some remarks on the construction of tuning forks. The ideal tuning fork consisted, he said, of two equal masses of metal moving toward and apart from each other at the same moment in such a way that their center of gravity remained the same. But the actual tuning fork of practice was not the ideal one of theory, for in it the balance was not complete and ought not, in his opinion, to be complete. To make it so the prongs should be bent inward. When that was done very little sound, and that chiefly the octave of the fundamental note, was propagated along the stem. Even in ordinary tuning forks held down in the usual manner on a sounding board, the greater part of the sound heard was the octave, which could only be discriminated from the fundamental tone after a good deal of practice. Lord Rayleigh then turned to the subject of vibrations under the influence of capillary tension and discussed the behavior of jets of liquid issuing under a certain amount of pressure from orifices of various shapes. If the orifice was circular, the jet remained circular for a considerable distance before breaking into drops. From an elliptical hole the jet was at first elliptical, it then became circular and afterward elliptical again, the major axis of the ellipse being, however, perpendicular to that of the ellipse first formed. With a triangular hole the effect was similar. The jet disposed itself into three sheets perpendicular to the sides of the orifice. The difficulty of experimenting with a column of water was pointed out, but it was shown that its behavior could be studied by throwing its image on the screen. It was thus possible to measure the periodic distances between the various changes of shape. The application of this method to answering the question, "Is the capillary tension of a surface the same when it is first formed as it is subsequently?" was explained, and it was stated that the tension of the newly-formed surface of soapy solutions was almost the same as that of pure water. The lecturer then considered the change of jets into drops. The process was illustrated by a number of photographs of jets in the course of resolution, and also by an experiment in which treacle was allowed to fall on a glass plate, when it was seen that the stream thus formed on the plate gradually contracted at some places and in others swelled out into beads or "varicosities." The distances between these contractions and thickenings was a question of wave length. A jet left to itself would probably form into drops in a somewhat irregular manner, but regularity could be obtained by special arrangements. The influence of electricity on a jet was next shown. When a piece of electrified sealing wax was brought close to a fine jet of water, the latter altered its character at once. Instead of scattering into a large number of very fine drops, it resolved itself into a few large ones. In conclusion, some methods of obtaining regular resolution of a jet were explained. It was essential to impress a definite vibration on it from the first. This might be done by means of a tuning fork, with which the drops would keep time; or another way was to allow the jet to strike something whose vibrations were communicated to the nozzle from which the water issued.

In the fifth lecture Lord Rayleigh, dealing with vibration in water jets, showed an arrangement by which a jet impinging on a disk connected by a wooden rod to the pipe from which the jet issued produced something approaching to a musical note. He then discussed at some length the conditions in which a jet breaks up into drops, and the ratio existing between the circumference of the jet and the distance between the drops. The complete explanation was difficult and depended on several variables, so that, although an approximately accurate general formula could be given, each jet had peculiarities of its own. A highly viscous fluid, for example, did not tend to gather up into drops, but, on the contrary, showed a progressive attenuation. In ordinary fluids, nevertheless, viscosity did not play so large a part as was supposed by Plateau. A horizontal jet breaking up into drops a short distance from the nozzle was shown to regain continuity under the influence of a tuning fork of appropriate pitch. The jet, however, continued to give off a fine spray, consisting, as the lecturer explained, of the ligaments of fluid which connect the larger drops at the moment of their separation. Under the influence of two sets of vibrations, differing, say, by an octave, the jet gave two streams of drops, the even numbers taking one path and the odd ones the other. This phenomenon was not understood by Plateau, and another careful experimenter, Mr. Chichester Bell, did not wholly agree with Lord Rayleigh. He, however, experimented with exceedingly fine jets in which some of the phenomena were to be ascribed to vortex motion—the center of the jet moving more rapidly than the circumference. Turning to the important subject of continuous vibration and the modes of maintaining it, Lord Rayleigh discussed at some length the principle of the electric tuning fork. He showed that the explanation which first suggests itself would not bear examination, since it could not explain the intermittent application of force at the proper instant. It was necessary that the forces should not depend solely on the position of the prongs, and, in fact, what made the electric tuning fork possible was the retardation or lag of the current. The dipper attached to the prong made a better contact on coming out of the mercury than on entering, and this difference sufficed to apply the impulse to the prong just at the instant when it was most effective in maintaining motion. Dealing next with a more familiar example of sustained vibration, the lecturer explained the production of sound in an organ pipe. Investigators did not seem to be thoroughly agreed on all points connected with the maintenance of the vibration, while it was yet more difficult to give a complete explanation of all the adjustments upon which, as organ builders are aware, depends the capacity of the pipe for "speech." Lord Rayleigh then gave examples of vibration maintained by heat. A small jet of burning hydrogen was shown to be capable of setting glass tubes and brass resonators into rapid vibration, producing musical sounds. There was a certain range of pitch, within which the flame acted with more or less effect, and one particular note which it called forth far more clearly than any other. The flame really corresponded to the bellows of the organ, while the tube or brass sphere held over it played the part of the organ pipe. Yet this was not a complete statement, since it was found that, by loosely plugging the hydrogen tube with cotton wool, the power of the jet to sing was wholly abolished. This proved that the musical effect was in part due to vibration within the column of gas, as well as to vibration in the resonator. A very effective experiment consisted in extracting a powerful musical note from a length of common iron pipe some six or eight inches in diameter. This was suspended from the roof, and contained at about a foot from its lower end a partition consisting of a few layers of common wire gauze. This gauze was heated for a few moments by a powerful Bunsen burner pushed up the pipe, and on its withdrawal the pipe, after a second or two of silence, gave out a deep booming note, which was sustained until the gauze cooled down. Here, as was explained, the sound depended upon vibration, together with a slight upward draught sufficient to bring fresh layers of air into contact with the gauze. If the pipe were turned upside down so that the gauze was nearer the top, the sound could be obtained only by keeping the gauze cool and sending hot air up the pipe.

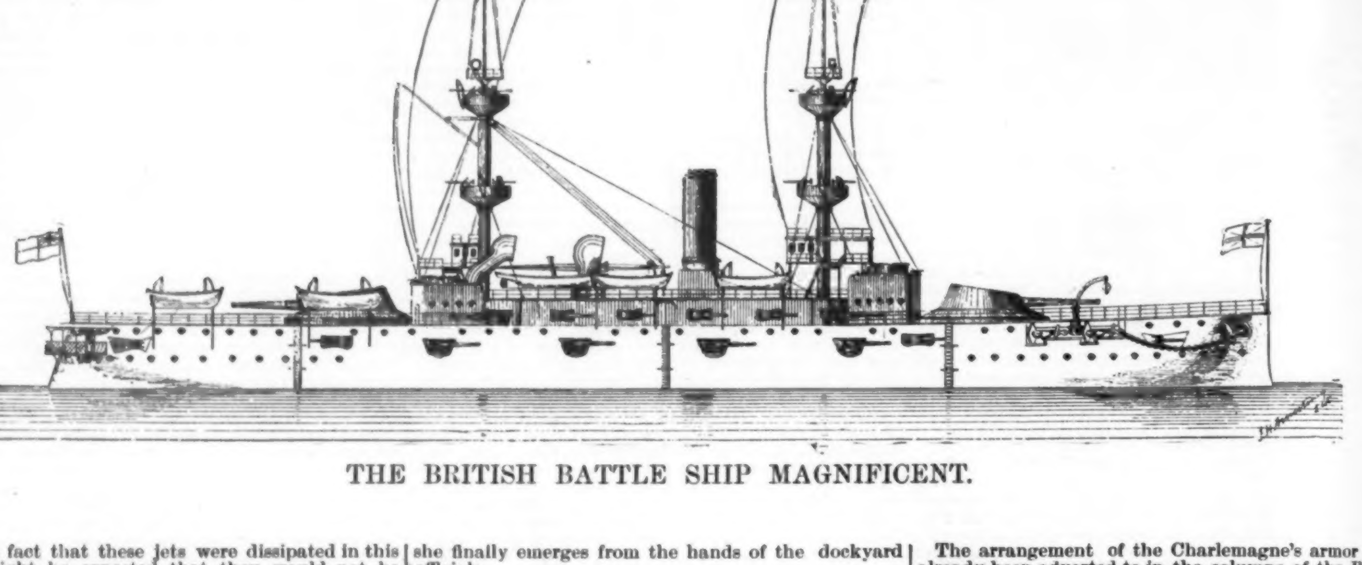
Lord Rayleigh, in his concluding lecture, discussed "sensitive" jets or flames which, under the influence of appropriate vibrations, flared or showed other signs of disturbance. Inquiring into the mode of this sensitiveness, he said that, as he had already explained, capillary force was the cause of the disintegration of a water jet issuing into air, and the jet gave way symmetrically round its axis. But with a jet of coal gas issuing into an atmosphere of coal gas

the conditions were different, and the instability of the jet was not dependent on capillary force. It did not disintegrate symmetrically, but became bent and sinuous. After describing a sensitive flame designed by himself, the particular advantage of which was that it could be used with the ordinary pressure of gas, the lecturer attacked the problem of the sensitiveness of the flame by considering the analogous case of a jet of water discharging in water, and concluded that the behavior of both gas and water jets of this kind was in the main dependent on the viscosity of the fluid employed. The water jet was seen to be sensitive to sounds of very much lower pitch than those which affected the gas jet. The manner of the disintegration was shown in a number of photographs, taken by instantaneous illumination, in which the sinuous course of the jet was very evident. From the fact that these jets were dissipated in this way it might be expected that they would not be equally sensitive in all directions, and such was found to be the case. The sounds might be supposed to reach a vertical jet horizontally, and, in fact, a jet sensitive to sounds coming from the north or south was but little affected by sounds from the east or west. Lord Rayleigh then turned to the question of the sensitiveness of the ear to sounds, and described some experiments he had undertaken to determine it. A little consideration would show that the ear was extremely sensitive, but measurements were not so easy. He had obtained some startling results. By one method he found that the ear was capable of responding to an amount of condensation and rarefaction in the air equal to one twenty-millionth of an atmosphere, though the result of another series of experiments conducted on a different plan went to prove that the amount of condensation heard was a tenth less than that figure. In conclusion, he briefly discussed the question how we knew from what direction a sound came. The point was one of considerable difficulty. The fact that we had two ears was supposed to supply an answer, since the right ear, if turned toward the sound, might be supposed to hear more than the left. That theory might hold for sounds coming from the side, but what if they were in front or behind? By experiment he had found that with pure sounds—such as were given by a tuning fork—the ear could tell with certainty their direction when they were to the right or left, but was quite at a loss if they were in front or behind. But with other sounds the case was different; the ear could easily judge the direction, whatever it was, of sounds such as were produced by the human voice or by clapping the hands.

THE BATTLE SHIPS MAGNIFICENT AND CHARLEMAGNE—A COMPARISON.

Two important types of battle ship are at the present moment being constructed in the naval dockyards of France and England respectively—those of the Charlemagne and Magnificent. The representatives of these two types, although widely differing from one another in many essential particulars, will undoubtedly, when afloat and in commission, be the most complete fighting machines in the world.

We engrave, for the sake especially of the interesting comparison they afford us, drawings of both vessels; but, although the Magnificent—the first of our engravings—is portrayed as she will actually appear, it is more than likely that the Charlemagne may be very materially modified in her upper works before she finally emerges from the hands of the dockyard officials.



THE BRITISH BATTLE SHIP MAGNIFICENT.

The accompanying table gives all particulars as to dimensions, constructive features, etc., of both ships:

Dimensions, etc.	Charlemagne.	Magnificent.
Length—feet—on water line	385	390
Beam—feet	66$\frac{1}{12}$	75
Draught—feet	25$\frac{11}{12}$	27½
Displacement—tons	11,232	14,900
Indicated horse power	14,000	12,000
Coal capacity—tons	1,100	1,800
Speed—knots	18	17½
Armored belt—inches	15¾	9
Barbette or turret armor—inches	15¾	14
Armored deck—inches	Two decks 3½ and 1½	One deck 4 and 3
Center of metal of heavy guns above water line—feet	forward 27$\frac{1}{12}$ aft 21$\frac{1}{3}$	forward and aft 27
Number of screw propellers	three	two
Armament—		
Main B. L. guns	Four 11¼in.	Four 12in.
Secondary heavy Q.F. guns	Ten 5½in. Six 4in.	Twelve 6in. 16 12-pdrs.
Smaller Q.F. guns	Thirty-six	Twelve
Machine guns	Nil	Eight
Torpedo tubes and dischargers	Ten	Five

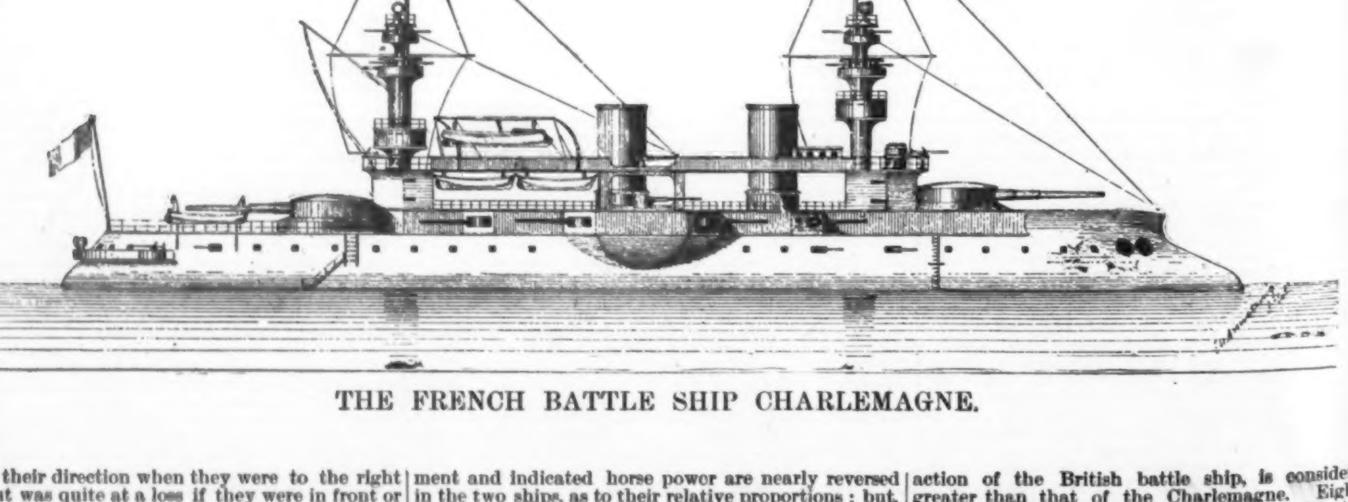
The first feature that strikes one is that displacement and indicated horse power are nearly reversed in the two ships, as to their relative proportions; but, of course, the extra engine power of the French vessel is mainly required for the third propeller, and we cannot admit that the result of experiments with triple screw vessels is so satisfactory as to cause us a feeling of regret that more powerful engines have not been designed for the Magnificent class. At the same time if 18 or 18½ knots is got out of the Charlemagne by applying all her screw power, it will give her maneuvering qualities superior to those of the British battle ships. This remains, however, to be proved.

The double armored decks of the Charlemagne are a valuable modification, and the cofferdam between them may prove to be a most useful adjunct to the water tight qualities of the ship; but it seems to us that, if the stability of the vessel was not disturbed by the arrangement, the two decks would have been more effective combined in one thickness. The turtle back deck of the Magnificent, stretching from bow to stern, and reaching down far over the sides amidships, with its four inches of steel, is superior, we believe, to the French cofferdam.

The arrangement of the Charlemagne's armor has already been adverted to in the columns of the Engineer. The method by which axial fire ahead and astern has been secured appears so likely to be detrimental to the safety of the vessel's upper works when the guns are trained directly fore and aft, that we cannot recommend it. But the plan of securing the upper deck battery of 5½ in. guns behind a complete belt of 3 in. armor cannot be too highly approved. The conning towers are also well placed, and at a commanding altitude, though it is a little difficult to understand what security is afforded to the officers in the forward one, in the event of the mast being shot away upon which it is perched, the latter not being armored.

The power of the armament mounted upon the Magnificent is incomparably superior to that of the French vessel. The twelve 6 in. quick firers upon the former, each with its isolated casemate protected by 6 in. steel, and the sixteen 12 pounder quick firers of the new Elswick pattern, compose an auxiliary armament so tremendous in its potency that no moderate sized cruiser could live in the vicinity of the battle ship, even if keeping under way at a rapid rate of steaming, so as to avoid the fire of the main armament of 12 in. heavy guns. The uniform height, 27 ft., of the British heavy guns above the water line is also a distinct advantage.

The total coal capacity, and consequent radius of action of the British battle ship, is considerably greater than that of the Charlemagne. Eighteen hundred tons of coal can, in emergency, be stowed away in the former, but the extreme capacity of the latter is only 1,100. This is an important characteristic for long sea voyages.—The Engineer, London.



THE FRENCH BATTLE SHIP CHARLEMAGNE.

THE LOSS OF THE REINA REGENTE.

THE sad intelligence is announced of the foundering at sea of the splendid armored cruiser of the Spanish navy, the Reina Regente, with loss of some 420 officers and crew. On the 10th of March the ship sailed from Tangier for Cadiz, and sank, it is believed, the following day during the prevalence of a great storm. The tips of her topmasts were found projecting from the water near Gibraltar and the Spanish coast.

The armored cruiser Reina Regente was built and engined by Messrs. James & George Thomson, of Clydebank, for the Spanish government, in 1886-1887. She was a vessel of considerable size, the following being her measurements: Length over all, 330 feet, and 307 feet between perpendiculars; breadth, 50½ feet; and her draught was 20 feet, giving a displacement of 5,000 tons, which was increased to 5,600 tons when she was fully equipped.

This vessel belonged to the internally protected type of war cruisers, a type of recent origin. The internal protection included an armored deck which consisted of steel plates ranging from 3½ inches in thickness in the flat center to 4¾ inches at the sloping sides of the deck. This protective deck covered the "vitals" of the ship, the machinery, boilers, etc. Then there was a very minute subdivision in the hull of the ship, there being, in all, 156 watertight compartments, 83 of which were between the armored deck and the one immediately above it.

Throughout her whole length the Reina Regente had a double bottom, which also extended from side to side of the ship.

Not being weighted by massive external armor, the Reina Regente was unusually light in proportion to her bulk, and in consequence it was possible to supply her with engines of extraordinary power. They were of the horizontal triple expansion type, driving twin screws, and placed in separate watertight compartments. The boilers, four in number, were also in separate compartments.

The engines were designed to indicate 12,000 horse power, and on the trial, when they were making 110 revolutions per minute, they indicated considerably upward of 11,000 horse power.

The vessel was capable of steaming 6,000 knots when there was a normal supply of coal in her bunkers, and when they were full there was sufficient to enable her to steam 13,000 knots.

When fitted out for actual service, this novel war cruiser had a most formidable armament, consisting of four 24 centimeter Hontorio guns (each of 21 tons), six 12 centimeter guns (also of the Hontorio type), six 6 pounder Nordenfelt guns, fourteen small guns, and five torpedo tubes—one at the stern, two amidships, and two at the bow of the ship.

THE SPANISH WAR SHIP REINA REGENTE.

NOVELTIES IN STEAM LAUNCHES.

THE launches which are on view at the Royal Aquarium, London, form part of the fisheries exhibition. There is besides these a good collection of rowing boats, canoes, etc., as well as of various appliances connected with boating. Most of the launches shown use petroleum as fuel. One of them, a mahogany boat, 22 ft. long, is exhibited by the Liquid Fuel Engineering Company, of East Cowes. The general arrangement of the boiler consists of copper tubes connected at the bottom just below the lamp and which all enter the steam drum near the top. These tubes are of seamless drawn copper, bent in a double curve to allow for expansion, and are fixed by means of a detachable joint, so as to enable any tube to be taken off by means of a spanner only for inspection or cleaning, without any necessity for packing or expanding the ends. The whole boiler is copper or brass, no steel or iron being used, but the casing is of galvanized iron lined with asbestos. This opens with a hinge, so that all parts of the boiler are easily accessible. The generator is a flat hollow plate placed just above the lamp. Partitions in this cause the oil to pass backward and forward a number of times, till it goes out in the form of gas to the burner. In the center of the burner is a weighted valve, by which the admission of gas is regulated according to pressure. A small lamp, made of asbestos wool, saturated with oil or spirit, is placed under the generator to start it, and oil admitted slowly. In five minutes the burner is working, and in fifteen minutes from everything cold there is a pressure of 100 lb. A hand air pump is connected with the oil tank; and as soon as there is 5 lb. or 6 lb. pressure from this, the oil will flow into the boiler, and the feed proceeds automatically. The same company exhibit the "Simplex" stockless anchor. This is in shape just like the ordinary Martin's anchor; made to fold flat when not in use. It is, however, differently made, and requires no fitting. The shank is first cast, in annealed steel, and then it is put into the mould, and the flukes are cast through it; the bearing surface being protected by asbestos or blacklead, to keep it from sticking. The smaller sizes are also made in gun metal or phosphor bronze.

Messrs. Simpson, Strickland & Co., of Dartmouth, show a yacht's launch 24 ft. long, fitted with Kingdon's patent quadruple expansion surface condensing machinery. These engines are beautifully made and very compact. They also show a Canadian canoe, 17 ft. 6 in. long, fitted with a one horse power high pressure condensing engine. This is probably the smallest engine ever made for a vessel of this size, as, together with the boiler, it occupies a space of 17 in. square. It is heated with liquid fuel, the burner being of the Wells type. The engine is 2 in. diameter and 2 in. stroke. The copper tube which forms the boiler can be easily taken out for cleaning. The boiler casing, engine framing, etc., are of aluminum. The oil for the feed is in a small tank under the thwart. It only holds a gallon, but is sufficient for fifteen or sixteen hours. The propeller is driven by means of a universal joint, and has the arrangement usual on boats of light draught, to enable it to be lifted out of the water.

Launches with petroleum motors are also shown by the Daimler Motor Syndicate, of Leadenhall Street, who exhibit several boats fitted with their patent motor.

The exhibitors say that there is no smell, that no skilled engineer is required, and that they have sufficient steam pressure to start running three minutes after they light the fire. A 1 horse power motor will drive one of the boats they exhibit, which is 23 ft. long, 4 ft. 11 in. beam, and 2 ft. 2½ in. deep, at the speed of six or seven miles an hour, with a consumption of fuel costing 1d. per hour. Besides launches they show patent propellers with reversible blades. One of these was fitted last year to the Porthegan lifeboat in Pembrokeshire, and is reported to be giving great satisfaction.

The British Aluminum Company has an attractive exhibit consisting of an aluminum naphtha launch. This boat, which was built by Messrs. Escher, Weiss & Co., of Zurich, was running regularly last summer between Windsor and Maidenhead. It is constructed of aluminum plates ⅛ in. thick, and weighs, when fully loaded, 850 lb. It is fitted with a 2 horse power naphtha engine, and is 17 ft. 9 in. long, 5 ft. broad, and 2 ft. 3 in. deep. The mean draught is 1 ft. 4 in., and the average speed is six miles an hour. The naphtha tank is in the bow, and the boat can be steered from either forward or aft. As shown at the exhibition a table is set for dinner in the middle of the boat, and the plates, cups, forks, spoons, and cooking utensils are all of aluminum.

Messrs. Desvignes & Co., Tedington, also exhibit a very handsome steam launch, which contains several novel points. It is fitted with their patent water tube boiler, weighing 540 lb., and consisting of 200 solid copper tubes, arranged in four batteries. These tubes are 18 B.W.G. thick, ⅝ in. external diameter, and 15 in. long. The working pressure is 180 lb. Mr. Desvignes was the designer of the celebrated high speed river launch, the Hibernia, the steamer used by the umpire of the Henley Regatta, and capable of making 26¾ miles per hour. She is 48 ft. long, 7 ft. 3 in. beam, and her engines indicate 130 horse power. The boat exhibited is 25 ft. long, 5 ft. 2 in. wide, and 2 ft. 6 in. deep. The draught to the bottom of the propeller is 17 in. The engine, which is 3½ in. diameter by 3 in. stroke, is a remarkable miniature, with extraordinary proportions with respect to the essentials of large working surfaces and steam passages.—The Engineer.

THE CLAY PIPE INDUSTRY.

THE clay from which the ordinary clay pipe is made is in its natural state of a slate color. It changes to white in firing. That used in pipe factories hereabout comes mainly from Woodbridge, N. J. As received it is in chunks, large and small, and in dust, something as soft coal comes, and its color is not unlike that of cement. The clay is soaked in tubs for ten or twelve hours, until it has been soaked into a mass, to prepare it for working. It is then put through a pug mill, in which it is mixed to make it of a uniform consistency and to bring it to the right temper; it should be like a stiff dough. As it comes from the pug mill it is made up into balls or bunches about the size of a peck measure. From the clay thus prepared, for use without any admixture whatever the pipes are made.

The first step in the process is the working of portions of the clay into what are called rolls. A bunch of the prepared clay is placed upon a bench and the roll maker picks off two lumps of clay, which he lays on a board in front of him on the bench. He rolls both lumps at once, one under each hand, rolling them out into elongated, tapering shapes, with the thick ends or heads toward the thumbs and the smaller ends tapering out on the little finger side of the hands. These are the first crude shapes of the pipe, though their resemblance to a pipe would not be detected if one did not know that that was what was to be made of them; the roll looks perhaps more like a horseshoe nail with a round instead of a flattened head, and a round instead of a flattened nail; or it may be of a shape quite different from that; its shape and the length of the stem part depending on the style of pipe to be made.

The rolls are laid on boards in bunches of dozens, and put away to stiffen; after ten or twelve hours they are ready for moulding. There are different kinds of moulds, varying in some minor details, but practically alike in operation. Some moulds are, however, much more elaborate in construction than others, the mould for an ordinary pipe being in two pieces, while the mould for a fancy pipe might be in a half a dozen or more pieces. A pipe factory might have hundreds of different moulds for almost as many styles of pipes. Moulds for plain pipes are made of iron, those for elaborate styles are sometimes made of brass or other compositions.

The mould for an ordinary clay pipe is of two parts,

hinged at the botton, and opening vertically lengthwise. By the pipemaker's side is a board of rolls. He holds by a handle at one end a wire that is to make the hole in the stem of the pipe. He picks up a roll and draws the stem part down on the wire, there is the hole in the stem of the pipe already made. He bends the head end up a little to make it go more easily into the mould, and that touch adds distinctly to the pipe look of the roll. He puts the roll in one side of the mould and shuts the mould up together and puts it in a press, bowl up. The closing together of the parts of the mould upon the pliable clay has already shaped the pipe upon the outside, and there is a hole through the stem, the wire still remaining in it, but it has no bowl. A single turn of a side screw holds the mould firmly in the press. Over the press is a lever to which is attached what is called a stopper, it is like a plunger attached to the underside of the lever by a pivot. When the lever is brought down the stopper is forced into the clay in the head of the mould, and so the bowl is formed. The mould is taken from the press and the surplus clay around the edges of the mould, pressed out when the mould was shut together, is shaved off with a knife; the wire is drawn from the stem, and the now completely formed pipe is set aside. The celerity with which the work is done is surprising. An expert pipe maker can make seventy-five gross of common pipes in a week; forty gross, however, would be about the average.

When the pipe comes from the mould, the clay still damp, it is a little darker in shade than the clay in its natural state. The bowl almost glistens in its smoothness. The new pipes are set away in racks to dry out somewhat before the next step in the process, the finishing. Ten or twelve hours in a temperature of seventy-five degrees is sufficient. There remains on the pipe a little seam where the mould has come together. In finishing the pipe a wire is run through the stem again to clear the hole if there should be any obstruction, and the wire serves also as a handle with which to hold the pipe. The seams are taken off, as is also the little burr of clay at the bottom of the bowl of the pipe over the hole from the stem. At this stage, too, the pipe is stamped with its brand, if it is to have one, if it is anything more elaborate than a simple letter or two on either side of the pipe. Designs are sometimes cut in the mould, but if it should be one across the pipe, the mould seam would run through it, and a smoother finish can be given by stamping after the pipe has come from the mould. Now the wire is drawn, and the pipe is set back on the board, and the board is again placed in the drying rack; this time the pipes are to be thoroughly dried, and twenty-four hours is about the time required.

Then the pipes are put into saggers, to be placed in the kiln. The sagger is a cylindrical shaped pot of fire clay, twelve or fifteen inches high, and about the same diameter. The longer stemmed pipes are laid in the sagger with regularity; the shorter stemmed, such pipes, for instance, as are to be finished later, with a stem piece of another material, and perhaps, to be colored in imitation of meerschaum, and which have stems so short that there is no danger of bending them, are simply laid in loosely. On the average a sagger will hold about a gross of pipes; of some pipes more, of others less, depending on the size. The saggers, filled, are stacked up in the kiln in stands, a kiln of ordinary dimensions holding twenty-one stands or stacks, nine high. The pipes are first subjected for about five hours to a comparatively mild heat, which is called soaking; then the full heat of the kiln is put on and continued for twelve or fourteen hours. Then the kiln is opened and the saggers are taken out, with the now completed pipes. They come out white.

Fancy clay pipes are made in the same manner as common clay pipes. In the making of the more elaborate pipes, as, for instance, one with a bowl in the semblance of a head, more elaborate moulds may be required. As stated above, moulds of half a dozen or more pieces are sometimes used. Of course it takes more time to make such pipes, but the general process followed is the same. The properties of the clays used in the manufacture of pipes are of course known, and the effect produced upon them by heat. The slate colored clays used as here described burn white; some red clays burn red, and some pink, and so on.

There are some familiar shapes of clay pipes that are standard and that are sold year after year constantly in great numbers. There are some other shapes and styles that are of steady sale; and fancy clay pipes are made in great variety; popular styles of wood pipes are reproduced in clay.

There are a number of clay pipe factories in this country, none of them very large, and most of them quite small. Their total output of pipes is considerable, but it is but a very small part of the total consumption of pipes in this country; probably not more than two per cent.

Most of the clay pipes we use are imported from Germany, Holland, Scotland, and France, in quantity in the order named, the greatest aggregate number coming from Germany, and the greatest number of fancy pipes from France. There has been but little change in the clay pipe industry in this country in recent years. Under the McKinley tariff of ten cents a gross it looked up somewhat; under the present tariff of ten per cent. ad valorem it is not increasing.

The foregoing is from a recent number of the New York Sun. An illustrated article on the same subject will be found in SUPPLEMENT 707.

HORIZONTAL BAND SAW.

THE band saw which we illustrate has been patented by Herr Landis, a sawmill owner, whose works are situated near Zurich, and the machine is now being made by Messrs. A. Ransome & Co., of the Stanley Works, Chelsea. As will be seen from our illustrations, which are from Engineering, the saw cuts horizontally instead of vertically. The frame of the machine consists in the main of two pillars fixed on each side of the log table. Surrounding each pillar is a sleeve, on the upper portion of which a multiple-threaded screw is cut, while at the bottom of each sleeve a wormwheel is fitted. These wheels are driven by two worms keyed on a shaft extending transversely across the machine underneath the table. Cutting is commenced with the saw in its highest position, and as each plank is cut off, the saw is lowered by rotating the handwheel shown on the right, which is connected to the wormshaft, already mentioned, by bevel gearing. The weight of the saw and its saddle, the pitch of the screw being quick, tends, it will be seen, to make the manipulation easy. A dial is fitted above the handwheel, and permits the thickness cut to be accurately regulated. The saw is raised again by power. The bearings supporting the pulley spindles are fitted on trunnions. Each of these trunnions, in the case of the right-hand pulley, is fitted on an arm, sliding telescope fashion in the main saddle casting. On the top of these arms a screw rack is cast, into which a worm gears, which affords a means of sliding the arms out and of getting the requisite tension in the saw. In order that the saw may run properly, however, it is necessary that the two spindles shall not be parallel to each other, and it is for this reason that the trunnion bearings are employed. The worm traversing the back telescopic arm can be uncoupled from its fellow in front, and this done, the forward arm alone is moved on turning the handwheel working the traversing gear. Having obtained a suitable inclination of the spindles to each other, the second arm can be put in gear by simply tightening a nut, and then the two arms move together till the requisite tension is obtained on the saw. The table, which is 28 feet long, is of iron, being constructed of two I beams rigidly connected together transversely. The under surfaces of these I beams are accurately planed and run on rollers bolted to the bedplate at frequent intervals. Care is taken in affixing these rollers that the upper surfaces lie accurately on one level. For feeding, a pitch chain running over a sprocket wheel is used, the ends being firmly attached to the table. The height below the saddle and the width between the columns is such that logs 4 feet square can be dealt with. A single man can manage the whole machine, the five handles used in working being all grouped together on the right. The first of these, working the lowering gear, has already been referred to, and the others will now be described. One of them throws a friction clutch into gear to raise the saddle again. This gear drives the lower worm spindle, which rotates the screwed sleeves, thus lifting the saddle. The second handle works a friction clutch, giving the forward feed, and the third handle runs the table back at a speed of 600 feet per minute. By means of the fourth handle the forward feed can be varied from 10 feet to 80 feet per minute. The whole of the above gearing is grouped together on the left of the machine, the links connecting it with the hand levers passing underneath the table. The arrangement is shown in Fig. 2, in which A represents the clutch used for raising the saw, B that for the quick return of the table, and C that for the forward feed. The gear for regulating the rate of feed is shown at D. It consists of a disk and roller friction gear. By moving the roller nearer the center of the disk the speed of rotation is, of course, reduced. Contact between the two is maintained by the use of a weighted lever. The machine is claimed to combine the functions of a breaking-down frame and a board-cutting machine. Indeed, it will almost cut veneers. It fulfills both of the functions, it is stated, more economically than any existing machine for either class of work, as it can be run very rapidly, 80 feet superficial of elm being cut per minute, and the saws used may be very thin, as little as 18 to 19 B. W. G. The waste is thus small. The boards produced are of even thickness and quite true. As it only requires one attendant to control the machine in addition to the laborer shifting the log, the wages bill can be reduced. It will be seen that the whole of the machine is fixed above ground level, so that no heavy excavation is required in erecting the plant. Two belts only are required for driving all motions; hence the machine can be run easily from a portable engine, and, being readily fixed, it is particularly suitable for forest work. For board sawing from logs a single Landis machine is said to do more work than ten ordinary horizontal frames, such as are generally used.

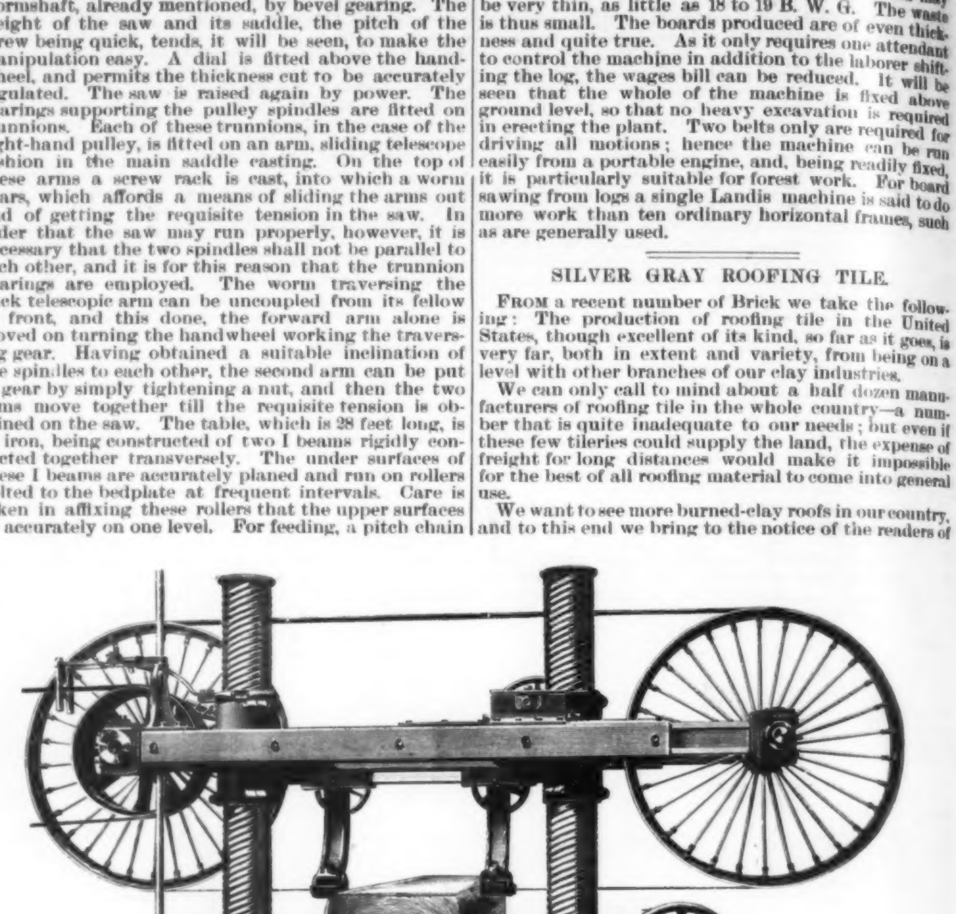


FIG. 1.

FIG. 2.

THE LANDIS HORIZONTAL LOG BAND SAW.

SILVER GRAY ROOFING TILE.

FROM a recent number of Brick we take the following: The production of roofing tile in the United States, though excellent of its kind, so far as it goes, is very far, both in extent and variety, from being on a level with other branches of our clay industries.

We can only call to mind about a half dozen manufacturers of roofing tile in the whole country—a number that is quite inadequate to our needs; but even if these few tileries could supply the land, the expense of freight for long distances would make it impossible for the best of all roofing material to come into general use.

We want to see more burned-clay roofs in our country, and to this end we bring to the notice of the readers of Brick a method of making roofing tile which appears to be quite unknown here.

The silver gray or "blue smoked" tile, first made in Holland and the lower Rhineland, is manufactured with success in various parts of Germany, notably at Freienwald on the Oder, where the Freienwalder Rathsziegelei belonging to J. F. Beneckendorf has for several years produced this special tile with great success, but it is strange that, notwithstanding the many advantages this tile possesses, it is not widely known, even in Europe.

The silver gray or, as the Germans call it, blue smoked (blaugedampfte) tile is a solution of the difficulty of making a roofing tile which, without being vitrified, is absolutely waterproof. A vitrified tile has many opponents, for the reasons that a heat sufficient to produce vitrification is very likely to warp and twist the tile; a vitrified tile, too, is very often brittle, for out of a kiln of roofing tile some are almost sure to be chilled, that is, struck by a current of cold air before the process of annealing, or very slow cooling, is completed. Consequently a tile is put on the market, the Ludowici, which claims to be superior to all others because it is not vitrified. But the vitrified tile men retort that this is only baked, not burned clay, and not far removed from adobe; that the non-vitrified tile is so soft the sparrows could scratch a hole through it and that its crude light color makes it an eyesore on the top of a good piece of architectural work.

The silver gray tile possesses the advantages of both the vitrified and non-vitrified kinds. It is not burned so hard as to be distorted and brittle, it has a subdued

color and is absolutely waterproof. The writer has taken one of these tiles and raising a border or frame of putty around it, poured water on, allowing it to stand for five or six days. No trace of moisture showed itself underneath any more than it would on a glass or thoroughly vitrified tile. A common roofing tile must be of exceptionally good quality that will not, under such a test, show beads of water on the under surface within an hour.

The silver gray tile is, briefly, a burned clay tile carbonized throughout, the graphite-like carbonization being produced at the conclusion of the burning process, somewhat as salt glazed ware is glazed when the burn is finished. The method of doing this we will now proceed to describe.

The tile may be of any shape or make, hand made, pressed or auger machine made. Very conveniently shaped are the corrugated tile which, when set in the kiln, give only small points of contact and at the same time form a number of tubes, through which the carbonizing vapor (blue smoke) can circulate. But any shape or kind of tile that can be burned can be "blue smoked."

Opinions differ as to the best size for the kiln. One authority, Jacob Buhrer, considers the kiln should be small, holding about 8,000 pressed or 10,000 auger machine tile. Though he admits it is very much a question of the amount of heat the clay will bear without falling down, and that kilns should be smaller for ware which burns very easily, while if the clay holds up well the kiln can be larger; but another authority, C. Jungst, contests this, citing the practice of the Freienwalder works, where the kilns hold 20,000 pressed lock-joint tile and give perfect results.

It is obvious that only tile can be burned in a kiln at one time and it takes two or three burns of ordinary ware before the tar, with which the kiln walls are saturated, is got out, and front, ornamental or glazed brick, can be burned without fear of discoloration. The time occupied in burning a kiln of silver gray tile is about as follows: 1½ days for setting, 3 days for water smoking, 1½ days for full heat burning, 6 to 7 days for cooling, 1 day to empty kiln; total, 13 to 14 days.

It is found an advantage to build the kilns, which are only fired from one side, in pairs back to back and run the two at the same time. These are the smaller kilns as worked by Buhrer, and the consumption of fuel (coal) is about four tons each. The chief burner must thoroughly understand his business and know how to raise the temperature to an equal degree throughout the entire mass of the ware. The more equal the temperature, the nearer perfection is the silver gray gloss, which should be alike on every tile in the kiln. It is advisable, and is, in fact, the usual course, to finish up the firing and get a white heat of equal intensity throughout the kiln, with small shingled or split wood, and it is very important that trial pieces be freely used, for without these, mistakes are very likely to be made.

The burning being complete and the chief burner seeing that he has an equal heat throughout the kiln, on the furthest side the same as near the fire, the next operation is to hermetically close the kiln as quickly as possible. Wet or damp sand has been previously heaped up at the fire boxes, as high as the doors. An assistant stands ready on the top of the kiln with a pail of daubing mud and a quantity of damp sand. The burner then throws about eight to ten shovelfuls of slack upon each fire, quickly shuts the doors and calls to his assistant to close the damper. This is done at once, daubed with mud and a layer of about eight inches of sand thrown on.

By this time the burner has completed the closing of the doors with sand; the peepholes in the roof have been closed and covered with sand. All this work must be done very smartly, as it is an advantage to hold the smoke or vapor in the kiln, which comes from the slack just thrown in. The kiln is then allowed to stand for half an hour to an hour and a half, so that the glow of the fire is equally distributed or, as burners say, "the fire settles." The time necessary for this is a matter of experiment and largely depends upon the size of the kiln. As a general rule, one hour is enough; after an hour and a half the heat falls too much.

Everything being ready and there being not an opening or crack or fissure in the kiln by which air can enter, the tar or oil is poured into the kiln. This is put in through siphon-shaped funnels, of which an illustration is given here.

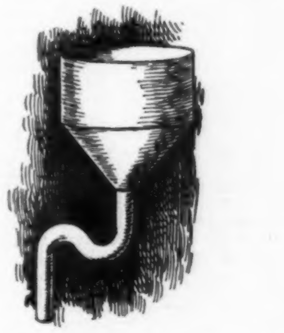
The object of the bent tube is to prevent admission of air at the time of pouring in the oil. Assuming that we use common coal or gas tar, seven pailfuls will be poured in, each pail holding between ten and eleven quarts. The tar or oil must not fall directly on the tile. When setting the ware two spaces are left, one each side of the kiln, and a layer of single brick arranged for the tar or oil to fall upon and vaporize. Two funnels are put into holes provided for them in the roof of the kiln. The joints well luted and further protected by wet sand. Half the blue-smoking material is poured into one funnel, half in the other. In three hours' time another seven pailfuls is poured in; this is done four times in all, so that the total quantity of tar used is about seventy-four gallons. It might be supposed that this great quantity of liquid tar, or oil, would spoil the contents of the kiln, but this is not the case. From the time the oil is first poured in, the sand, with which the roof is covered, is kept wet. If a row of kilns, say ten or twelve, are always used for blue-smoked tile, it is well to have water laid on permanently through an inch or inch and a half iron pipe along the kilns at the height of the roof, with branches at each kiln, upon which a rubber hose can be fixed. Where such an arrangement is not used, water is thrown on the kiln, five pails of water every hour and a half, day and night, for thrice twenty-four hours, then every two and a half hours until the kiln is cool enough to open.

For a set of ten or twelve kilns, each holding from 3,000 to 4,000 tile, two burners and two assistants are enough for day and night service and are able to burn from twenty-three to thirty kilns per month. The assistants, in addition to helping when closing the kiln, wheel the fuel, clear away the ashes, close and open the kiln doors, and keep the sand damp on roof and other places where it is used for sealing all openings.

The pouring in of the oil should, if possible, be done by the chief burner himself, so that he may be quite certain the right quantity is used, and for this operation of pouring in the oil or liquid tar, a watering can, from which the rose has been taken off, is more convenient than a pail.

As for the cooling of the kiln, the quicker this can be done the better, but we reckon it to take seven or eight days. When it is believed that all the fire is dead, the opening of the kiln is commenced, very carefully and very tentatively at first, for the kiln must absolutely not be opened so long as there is the least chance of the vapor in it igniting, as this would ruin the color and appearance of the tile. The fire doors are opened one at a time and as little as possible, sufficiently to draw out the ashes, for these hold the fire longest. This work should be finished quickly. The burner then goes on the roof, one of the peep holes is opened (there are usually three on a kiln twenty-five feet long). He cannot see into the kiln, in consequence of the vapor which continually rises, but the hole is left open for about five minutes, when, taking a sack he strikes some smart blows with it upon the mouth of the hole, when he will very soon see if there is any fire in the kiln, for sparks will come out of the hole and these can be seen very plainly at night. If sparks appear, the opening must be closed at once, and covered with sand and the fire doors daubed tightly.

In an hour's time this can be tried again, but if no sparks are seen, the further opening of the kiln may be proceeded with. All the view holes are opened and the sand packing is removed from the kiln door and a small hole is broken through the inner door. In three hours' time this hole is enlarged, and after a further six hours the whole of the door can be broken down, so that the setting is seen. Up to this time the fire door and chimney damper remain closed. After waiting another six hours the fire doors can be opened a little, but care must be taken not to open up too quickly, particularly if the clay is of such a nature that it will not bear rapid cooling, for the bottom rows of tile which lie on the flue openings will craze and fly. Six hours later the fire doors can be all quite open, so that after twenty-one hours' cooling, the outer air streams through the kiln; but even then the chimney damper is kept closed, otherwise the draught or current of cold air would be too great and cause chills or cold cracks. The damper should only be opened a few hours before emptying the kiln. This is the usual practice, though there are burners handling much smaller kilns who do not throw water on them, which is of course very trying to the brick work, but wait for seventy-two hours. Then open the fire doors, after



this the kiln doors, beginning at the bottom, are opened by degrees. The kiln stands like this for a time, then the chimney damper is opened. This creates a strong draught, and in about another twenty-four hours the kiln is cool enough to empty. But this plan, it should be observed, can only be adopted with certain kinds of clays.

As to which are the most suitable clays for the blue-smoking process, this, too, can only be determined by experiment. The prevailing opinion that a considerable quantity of iron must be present in the clay is a mistake. The method used at Tegeln, in Holland, which we propose to fully discuss in a future article, possibly requires that iron shall be a constituent, but where the blue smoking is done with liquid tar or oil, iron is not necessary, and it is found that clays containing lime, burning a yellow color, and even pure kaolin, will take the finest silver gray color. This process is specially adapted to clays which, when burned, prove very porous, but we must caution our readers against assuming that any and every clay will do. Tiles made from certain clays, apparently thoroughly sound, with a good ring, and free from craze or crack, have been found unable to withstand the first severe winter. An analysis of the clay will not tell us whether it will give a good tile; experiment alone will do this, and the test is better made by some disinterested and impartial person. A half dozen or so average specimens of the tile can be sent to a chemical laboratory, where the testing of clay is a specialty, and they would be submitted to all the destructive influences which nature would bring to bear in the course of years. If the cost of such a test is objected to, and time is of little importance, the tile maker can carry out his own test by putting up a small roof, which should be in the most exposed position that can be got, and if, after the second winter, the tile is found to be absolutely unchanged, the production of them on a manufacturing scale may be commenced with confidence.

The cost of manufacturing silver gray tile in Germany has been found to be $1.80 per thousand more than the same tile burned red in a continuous kiln, which is, of course, the very cheapest way of burning. The items are as follows:

Extra cost per M for labor	$0.42
Tar or oil	.53
Extra coal	.85
	$1.80

A prime condition of success is the selection of an intelligent and careful chief burner, who knows his business, and who will insure the kiln being absolutely air-tight during the blue smoking process, but he must be given the right materials to work with, or failure may be due to causes over which he has no control. The oil (we are not now speaking of liquid tar) which is mostly refuse from the oil refineries, may contain injurious constituents producing minute cracks in the tile, cracks so small as to be invisible to the naked eye. The tile may even ring, but it will not last over one severe winter. In one car load of oil there may be some barrels of a more inflammable character and which do not possess the property of quickly deadening the fire; in such case a larger quantity of the oil must be used or the ware will not be perfect. Coal which does not produce a long flame will be found to be unsuitable for the blue smoking process, the more so that the kilns are fired from only one side. Where this is the only fuel obtainable, it has to be supplemented by the use of a considerable quantity of split wood, and the burning must be finished entirely with this wood.

This brings us to the question of the most suitable fuel. Our manufacturers in many parts of the country possess exceptional advantages for burning fine ware, such as roofing tile, in a plentiful supply of a most admirable fuel, crude oil.

We have no doubt crude oil would prove the very best fuel for the work described above, combining in itself the advantages of coal and wood, and we anticipate that crude oil would perfectly supply the place of coal tar or the oil refinery refuse used in Germany for the actual blue smoking.

By using fuel oil we should expect, if the burning and blue smoking is properly done and the clay is not very difficult to handle, that it would not be a question of what percentage of good ware could be got from the kiln, but that every tile would be a good and salable article and all be of equal color.

A tile such as is here described would, we feel sure, be a welcome variety to architects and command a ready sale.

We know well that the dark and neutral tinted slate and the subdued tones of old shingle or thatch are the most satisfactory roofing materials, so far as appearance goes, and are a great ornament to a building.

The facade of a house may be rich and imposing, or chastely beautiful, but if the roof be yellowish white or pink or pale red, the value of the whole, as an artistic effort, is diminished.

A dark red tile is far better; but it is undeniable that a neutral tint is the best of all and a roof so tinted is a finish and a frame to the rest of the architectural picture and a neutral color tone is the more desirable if the surface of the roof is broken by turrets, returns or dormers.

SILVER ALLOYS.

By G. J. FOWLER, M.Sc., and P. J. HARTOG, B.Sc.

THE following notes form a record of some experiments undertaken* for the purpose of obtaining a silver alloy, which should possess the whiteness of silver, without its liability to tarnish, and should also be capable of electro-deposition. Our endeavors proved unsuccessful, but the results obtained are of some interest. Our experiments fall into two divisions:

(I.) The preparation of alloys by fusion of their constituents.

(II.) The deposition of alloys by electrolysis.

(I.) Some time ago a company was formed for electro-plating with an alloy of silver and cadmium, which was stated to be much less tarnishable than silver. For various reasons the company did not meet with great success, one being, doubtless, that the expectations with regard to the alloy were not realized in practice.

We have found indeed in all cases that the silver alloys we prepared were more easily tarnishable than pure silver; on the other hand, a sulphide stain is in general more easily removed from the alloy than from the metal. We tested the alloys by the following rough but efficient means: two drops of ammonium sulphide were placed on the burnished surfaces of the alloy and of pure silver, respectively, at the same time, and removed at the same time, after an interval of a minute or two. It was then evident in all cases that the stain on the alloy was deeper in color than that on the silver, while it was in general more easily rubbed off with a piece of chamois leather.

It is of course well known that silver sulphide forms a particularly good and tenacious coating on silver; it was to be expected that a heterogeneous mixture of sulphides would be less tenacious. The following lines contain a brief description of the alloys prepared.

1. Silver Zinc Alloys.—The zinc was melted in a crucible under powdered charcoal, the molten silver added, the mixture stirred with an iron rod and poured into a mould.

(a) Ag 95 per cent., Zn 5 per cent. Color somewhat grayer than that of pure silver, but not easily distinguishable from it.

(b) Ag 93 per cent., Zn 7 per cent. Color easily distinguishable from that of pure silver.

(c) Ag 90 per cent., Zn 10 per cent. Still malleable, but grayer.

2. Silver Nickel Alloys.—These were obtained by melting the two metals together in a wind furnace under a layer of charcoal, stirring and pouring into a mould.

(a) Ag 95 per cent., Ni 5 per cent. Color was good, silver-like, and the alloy takes a high polish.

(b) Ag 90 per cent., Ni 10 per cent. Color was "steely," the alloy malleable.

Both these alloys tarnish readily, and the stain is not very easily removed from their surface.

3. Silver, Nickel, and Zinc Alloy.—Ag 90 per cent., Ni 5 per cent., Zn 5 per cent. The silver and nickel were melted together and poured on to the molten zinc, the contents of the two crucibles being covered with powdered charcoal. Color too gray, malleable.

4. Silver Aluminum Alloy.—Ag 90 per cent., Al 10 per cent. This alloy was highly crystalline and brittle; it broke to pieces on rolling. The surface was white and highly lustrous, but readily tarnishable.

5. Silver Tin Alloy.—Ag 95 per cent., tin 5 per cent. (by analysis).—According to Hiorns (Mixed Metals, 320), "the smallest quantity of tin renders silver brittle." This alloy is, however, perfectly malleable, yielding long spiral drillings. It has an excellent color and yields stains which are easily removable. Unfortu-

* At the suggestion of Messrs. Levetus Bros., of Birmingham.

nately tin is not easily deposited by the current, and the alloy is therefore unsuitable for our purpose.

6. Silver-Copper-Zinc Alloys.—In this case the silver and copper were melted together and added to the zinc, the operation being in other ways similar to that described previously.

(a) Ag 75 per cent., Cu 15 per cent., Zn 10 per cent.—Color too yellow. Malleable. Stain readily removable.

(b) Ag 67·87, Cu 5·17, Zn 27·47.—Showed signs of brittleness on rolling; color yellow and wanting in brilliancy. This alloy was analyzed, and it was found that by operating in our usual way that no loss of zinc was incurred.

(c) The above alloy was melted with a further quantity of zinc till the fracture was highly crystalline and of a bluish white color. The percentage of silver was found on analysis to be 30·74.

Electro Deposition of Alloys.—The efforts of technical chemists have hitherto been directed to the separation of metals by electrical methods, rather than to their deposition simultaneously; but for some years the electro-deposition of brass and other alloys has become a commercial process. The mechanism of the process, however, is by no means easy to understand. An interesting but incomplete note on the subject is due to Dr. Silvanus Thompson (Proc. Roy. Soc., 42, 387, 1887), who shows that since, owing to imperfect diffusion, the counter electro-motive forces at the cathode depend on the current density, and since the variations of E. M. F., due to differences of concentration, are greater for copper than for zinc, we can adjust the current density so as to obtain copper and zinc deposited in nearly equal quantities.

The law given by Berzelius to the effect that the most electro-negative metal is deposited first in electrolysis, is said by Ponthière (Traité d'Electro Métallurgie, Second Edition, 1891, 165) to be reversed when we use an anode composed of an alloy. For the present we shall only record the results of our experiments without discussing them. We hope at some future time to pursue the matter further.

We used in all cases a laminar cathode of German silver or Britannia metal, having a surface of about 4 square inches, on each face. The cathode was greased, so that the deposit could be stripped off and analyzed.

1. Deposition from Silver-Zinc Solutions.—A solution of the cyanides of the metals in excess of potassium cyanide, together with excess of ammonia, was used. 17·15 grammes of silver per liter (about 2½ ounces of silver to the gallon) were dissolved, together with zinc in the proportion present in alloy 1 (a). This alloy was used as anode. The specific gravity of the solution was 1·038. On heating to 40° C., a current of one ampere produced a good deposit, which was found to contain 99·8 of silver. Under these conditions practically no zinc is deposited.

2. Deposition of Silver, Copper and Zinc.—A cyanide solution was made containing the above metals, in the proportions present in alloy 6 (b). The amount of silver per liter was the same as in solution described above. Alloy 6 (c) was used as anode. With a current from four Bunsen cells the deposit was fairly even, but on analysis, was found to contain only about 1 per cent. of copper and zinc together.

The above solution was now mixed with an equal volume of brassing solution from which a good deposit of brass could be obtained with the current from two Bunsen cells. On analyzing the deposit from the mixed solutions heated to 40° C., only a small amount of copper was found. With four Bunsen cells a black deposit (probably oxide) was given by this solution.

On increasing the amount of brassing solution the amount of copper in the deposit increased, until, when the amount of silver originally present in the solution was zero, a brass was obtained containing a little silver.

We have not worked out the exact conditions for obtaining an alloy containing an equal proportion of the three metals, silver, copper, and zinc; but it is evident that the amount of silver present in the solution and in the anode must be much in defect of the proportion required for the alloy.

3. Deposition from Solution Containing Aluminum.—In 1855 Thomas and Tilley took out patents (Nos. 2,724 and 2,756) for depositing alloys of aluminum and silver, aluminum, silver and copper, etc. A solution of aluminum hydrate in potassium cyanide, or in a mixture of sodium carbonate and potassium cyanide, was used in their experiments.

We found that aluminum hydrate does not readily dissolve in potassium cyanide alone, for which we therefore substituted a mixture of caustic potash and potassium cyanide.

A cyanide solution was prepared containing aluminum and silver in the proportions present in the alloy (17·15 grammes of silver being dissolved per liter). On analyzing the deposit given by this solution with a current of about 6 amperes, it was found to contain not more than 0·8 per cent. of aluminum.

A solution of aluminum was prepared containing 70 grammes of aluminum nitrate to the liter, the alumina then precipitated and redissolved in excess of potash and potassium cyanide. Using the silver alloy with 10 per cent. of aluminum as anode and a current of 8 or 9 amperes, at a temperature of about 50° C., a deposit was obtained which still consisted almost entirely of silver, only a faint precipitate being given by ammonia, after precipitating the silver as chloride and filtering.

Our results therefore tend to confirm those of C. Winkler (Chemical News, vol. xxvi., p. 157; Jour. Chem. Soc., New Series, vol. x., p. 1134), who states that plating with aluminum cannot be effected by electro-deposition.

DISCUSSION.

The chairman said that the paper now carried him back nearly thirty years, to the first research work he did under the late Professor Graham at the Mint on a series of nickel and silver alloys, in which considerable difficulty was experienced owing to their segregation and lack of uniformity. On rolling out the buttons obtained, the lack of homogeneity was at once apparent. He would like to ask the exact conditions under which these fused alloys were prepared. Were they quickly cooled? In his own case he believed most were cooled slowly.

Mr. R. Pettigrew stated that silver alloys could be electro-deposited on a commercial scale, and he had two years ago, at a meeting of the Institute of Electrical Engineers, in London, shown, along with samples of every metal which could be electro-deposited, specimens of plates plated with an alloy of silver and cadmium, the percentage composition varying on the one side from 90 per cent. silver and 10 per cent. cadmium to 90 per cent. cadmium and 10 per cent. silver. The difficulty was not in getting these metals to deposit together as an alloy, but to regulate the current density and other features when an alloy process is worked on a commercial scale and where articles of varying size are plated, so as to get an even composition on all parts of the plated goods. The deposit on the inside of a large vessel, for instance, had often a different percentage composition from that on the outside, and hence a different color readily detected by the experienced eye. This difficulty could, however, be got over by using varying sized baths, according to the class of articles to be plated, and keeping the articles moving. The percentage composition of electro-deposited alloys depended on many features, among others the current density, chemical composition of bath, relative amounts of metals in the bath to each other, free cyanide and impurities, as well as to the position of the metals to each other in the electro-negative series; and he had found that silver and cadmium fulfilled the conditions more closely than any of the metals mentioned by the authors. He had tried electro-depositing zinc and silver together, but with a far less quantity of silver present than mentioned in the paper, and found that even with as low as an eighth of an ounce of silver to the gallon and a pound of zinc, he only got down from 5 to 7 per cent. of zinc; and even then it was not possible on a large scale, owing to the large current density required, making the surface rough. Again zinc was so difficultly soluble in potassium cyanide that the zinc cyanide formed on the alloy anode could hardly be got to dissolve, even when an excessive amount of free cyanide was present. He had never tried tin and silver or aluminum and silver in aqueous solutions, because tin was such a difficult metal to manage by itself in electro-deposition that it was hopeless to get it satisfactorily as an alloy. Aluminum he never considered suitable, because it had yet to be got by itself from an aqueous solution, at least with current density suitable for silver plating, and in the analysis given in the paper he rather thought the aluminum got had not existed as metal, but oxide. He had, however, succeeded in depositing these metals satisfactorily from fused salts, but of course this was out of the question for electro plating. With regard to fused alloys with silver, he could corroborate most of what was said in the paper, and gave an instance of an alloy of silver 92·5 and aluminum 7·5 which was so brittle that when he tried to scratch figures on it, it came away in fine powder—in fact, an ingot ¼ inch thick could be broken between the fingers. He also had noticed that alloys often had fine colors, and mentioned one of silver 60 per cent. and cadmium 40 per cent. which was hard and brittle, but the fracture of which had a lovely pink color. Mention had been made in the paper of the tarnishing of silver as compared with electro-deposited alloys, but his experience was that electro-deposited alloys tarnished less rapidly than pure silver, and then the tarnish which did form was more easily removed and was of a brown color—not the well known purple tarnish of pure silver. Fused alloys acted somewhat differently, and the difference of action had something to do with the chemical compounds formed, for a true alloy did not act as a mere mixture; and he had found that a standard alloy of copper and silver tarnished in spots and streaks, which tended somewhat to show that this alloy was not a definite compound but a mechanical mixture. Zinc and silver alloys he found tarnished usually of a grayish color. The properties of electro-deposited and fused alloys had little relation to each other, as he considered that an electro-deposited alloy was not a definite compound, but merely, as it were, a mechanical mixture. The author gave their method of testing the luster, but he considered it much better to work with a number of plates set in an oblong box, so that the number of reflections from a given point could be ascertained.—Journal of the Society of Chemical Industry.

SORGHUM FOR FORAGE.

You take great interest in the introduction of alfalfa clover for hay and fodder, which is right in my estimation. But you lose sight of the most valuable hay, or rather fodder, plant for the average farmer to raise as a sure crop for feed in winter, and that is the old, time-tried sorghum cane plant. No farmer can afford to raise anything else for a feed crop. Millet or Hungarian is nowhere to cane, neither in value as feed nor in quantity of tons per acre, nor to stand drought or chinch bugs. There are many of our upland farmers who, if they had sown four or five acres of cane for feed last year could have done well. The cane would have made all the feed they wanted for their stock and they could have sold their wild or prairie hay that they now have to feed, and could have made a good profit in doing so. But they depend on corn fodder to too great an extent, and at times like the past season has been it makes it too expensive, when sorghum can be raised so cheaply and without any care, simply by plowing the ground well in May or June and sowing the seed and harrowing in, or better, drill same as wheat, and you are done till time to mow the hay. Do not cut too soon. Let it head out but not get too ripe. It is the best when in blossom. Cut and let dry and rake in windrows and take the hay gatherer and put it in large shocks and let it stand until wanted. Put one ton or more in shock. It will keep all winter in fine condition, and the stock will eat it and get fat on it if given all they want. But if fed as I have seen stock fed, by putting a few straws to them once a day, and then have a protection of the north side of a three-strand barb-wire fence, they will not do for export beef next spring. A man might as well think of keeping warm with the thermometer ten degrees below zero by lighting a match once or twice a day. This would be as much sense as some men use in feeding stock. The farmer who will feed and care for stock well is the farmer who will succeed in the end.

Sorghum cane is the best feed for a substitute for hay that I know of to-day. I have tried Kaffir corn and millo maize, and they don't take the place of sorghum. They are non-saccharine, and sweet is what produces fat. Sour is anti-fat. There is no kind of stock that will not eat cane if it is put in the right shape. Some cut it too soon. If you cut it before it heads, it is watery and rank and stock don't like it. It is the same as green corn before it gets in tassel. I would advise farmers to sow largely of cane and secure the seed early this year, as seed is scarce, as the seed crop is light and there is a combine or trust trying to corner all of the cane seed in this State. The seed crop of last year was short 40,000 bushels and seed will be high. There will be a rush in the spring to get seed. The man that gets his seed early is the lucky man this year.—Kansas Farmer.

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